IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Patent Application of	)	
	)	Group Art Unit: 2833
Allan M. SCHROCK, et al.	)	
	)	Examiner: Thanh S. Phan
Appln. No.: 10/086,644	)	
	)	Attorney Reference: 005127.00197
Filed: February 28, 2002	)	
	)	Confirmation No.: 6973
For: PACE CALCULATION WATCH	)	

APPEAL BRIEF

Commissioner for Patents
U.S. Patent and Trademark Office
Customer Service Window
Randolph Building
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On Behalf of NIKE, Inc.

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APPEAL BRIEF

Commissioner for Patents
U.S. Patent and Trademark Office
Alexandria, Virginia

Sir:

Appellants submit this Brief in support of its appeal to the Board of Patent Appeals and Interferences from the decision of the Primary Examiner finally rejecting claims 1-51 in this patent application. For the reasons set forth in detail below, Appellants respectfully submit that the Primary Examiner's final rejection of these claims constitutes reversible error, and therefore, the Board should reverse the rejections of these claims.

(i) Real Party In Interest (37 C.F.R. § 41.37(c)(1)(i))

The real party in interest in this Appeal is NIKE, Inc., a corporation organized and existing under the laws of the State of Oregon in the United States of America, and having a place of business at One Bowerman Drive, Beaverton, Oregon 97005-6453. The Assignment of this application from the inventors to NIKE, Inc. was recorded in the U.S. Patent and Trademark Office records on May 22, 2002 at Reel 012924, Frame 0439.

(ii) Related Appeals and Interferences (37 C.F.R. § 41.37(c)(1)(ii))

Appellants, the Assignee, and the undersigned legal representative of the Appellants and Assignee are unaware of any appeals or interferences related to the present Appeal.

(iii) Status of Claims (37 C.F.R. § 41.37(c)(1)(iii))

Claims 1-51 (reproduced for reference in the "Claims Appendix") are pending in this application, with claims 1, 13, 27, and 41 being independent claims. In a Final Office Action dated August 13, 2004, the Primary Examiner rejected each of claims 1-51. Specifically, the Primary Examiner rejected claims 9, 15, 30, and 44 under 35 U.S.C. § 112, second paragraph. Additionally, the Primary Examiner rejected claims 1-8, 10-14, 16-29, 31-43 and 45-51 under 35 U.S.C. § 103(a) based on U.S. Patent No. 5,050,141 to Thinesen (Evidence Appendix A, hereinafter "Thinesen) in view of U.S. Patent No. 5,526,290 to Kanzaki (Evidence Appendix B, hereinafter "Kanzaki"). The Primary Examiner additionally rejected claims 9, 15, 30 and 44

over the combination of the Thinesen and Kanzaki patents, in further view of U.S. Patent No. 5,771,399 to Fishman (Evidence Appendix C, hereinafter "Fishman").

With respect to the rejection of claims 9, 15, 30, and 44 under 35 U.S.C. § 112, second paragraph, the Examiner indicated during a personal interview on December 20, 2004, that this "rejection is inadequate and will be withdrawn." *See* the Interview Summary Record dated December 20, 2004, included in Evidence Appendix D. Accordingly, Appellants present this Appeal Brief with the understanding that the rejection under 35 U.S.C. § 112, second paragraph, is withdrawn, and Appellants therefore appeal the final rejections of claims 1-51 under 35 U.S.C. § 103(a).

(iv) Status of Amendments (37 C.F.R. § 41.37(c)(1)(iv))

No amendments have been made to the claims following the Final Office Action dated August 13, 2004.

(v) Summary of Claimed Subject Matter (37 C.F.R. § 41.37(c)(1)(v))

The present invention involves a pace calculation device and a manner of using such a device. The following summary of the claimed subject matter identifies examples of portions of the original specification and drawings at which the various claim features are described or illustrated. The various claim features and the claimed subject matter may be described, discussed, and/or illustrated at other portions of the specification and/or in additional drawings not expressly identified in the summary that follows.

A summary of the claimed subject matter for each independent claim involved in this appeal follows:

(a) Claim 1

Appellants' claim 1 recites a device for calculating a pace (*see* page 3, line 17-18; page 3, lines 24-25; and Fig. 1, reference number 101). The claimed pace calculation device includes a chronograph for measuring an elapsed time (*see* page 4, lines 7-15; page 4, lines 16-18; page 4, lines 23-25; page 5, lines 9-16; page 6, lines 6-8; page 6, lines 13-17; page 7, lines 3-28; page 10, lines 3-12; page 11, lines 16-25; and Fig. 1, reference number 107). The pace calculation device also includes a distance memory storing a distance (*see* page 5, lines 1-8; page 5, lines 18-23;

page 8, lines 8-15; page 9, lines 10-15; page 11, line 28 through page 12, line 3; page 12, line 29 through page 13, line 2; and Fig. 1, reference number 115). The device further includes a system for performing a pace calculation process that calculates the pace by dividing the distance contained in the distance memory 115 by the elapsed time provided by the chronograph 107 (*see* page 5, lines 1 through 23; page 6, lines 16-17; page 7, lines 3-5; page 8, lines 8-15; page 10, lines 4-16; page 11, line 16 through page 14; page 12, line 23 through page 13, line 17; Fig. 1, reference number 113; and the flowchart of Fig. 3).

(b) Claim 13

Appellants' independent claim 13 recites a method of calculating a pace with a pace calculation device. *See* generally the flowchart of Fig. 3. As part of this method, a distance parameter is received into a distance memory of the pace calculation device (*see* page 8, lines 8-15; page 9, line 24 through page 10, line 3; and Fig. 3, reference number 303). As another part of this method, the elapsed time to cover the distance is measured with a chronograph, *e.g.*, by starting and stopping a counter of the chronograph at the appropriate times (*see* page 10, line 4 through page 11, line 28; and Fig. 3, reference numbers 305 and 307). Thereafter, the pace is calculated by dividing the distance contained in the distance memory by the elapsed time provided by the chronograph (*see* page 11, line 20 through page 12, line 14; and Fig. 3, reference number 309).

(c) Claim 27

Appellants' independent claim 27 recites a method of calculating a pace. *See* generally the flowchart of Fig. 3. This claimed method includes inputting a distance into a distance memory of a pace calculation device (*see* page 8, lines 8-15; page 9, line 24 through page 10, line 3; and Fig. 3, reference number 303). The method further includes prompting the pace calculation device to measure an elapsed time (*see* page 10, line 4 through page 11, line 28; and Fig. 3, reference numbers 305 and 307). Thereafter, the pace calculation device is prompted to calculate the pace by dividing the distance by the elapsed time (*see* page 11, line 20 through page 12, line 14; and Fig. 3, reference number 309).

(d) Claim 41

Appellants' independent claim 41 recites a method of calculating a pace with a pace calculation device. This claimed method includes receiving a distance into a distance memory of

a pace calculation device (*see* page 8, lines 8-15; and page 9, line 24 through page 10, line 3). Further, in this claimed method, a plurality of split times are measured with the pace calculation device, each split time being a segment of a total elapsed time (*see* page 10, lines 17-29; and page 12, line 23 through page 13, line 17). In this claimed method, the device further can determine the number of measured split times (*see* page 10, lines 23-25) and the segment distance (obtained by dividing the overall distance by the determined number of measured split times) (*see* page 13, lines 6-11). Finally, the claimed method in accordance with this aspect of the invention further calculates the pace of a measured split time by dividing the segment distance by at least one of the measured split times (*see* page 13, lines 12-17).

(vi) Grounds of Rejection to be Reviewed on Appeal (37 C.F.R. § 41.37(c)(1)(vi))

In the Final Office Action mailed August 13, 2004, the Primary Examiner finally rejected claims 1-51, the claims involved in this Appeal, based on the following grounds of rejection:

(a) Claims 1-8, 10-14, 16-29, 31-43 and 45-51 were rejected under 35 U.S.C. § 103(a) based on U.S. Patent No. 5,050,141 to Thinesen (*see* Evidence Appendix A) in view of U.S. Patent No. 5,526,290 to Kanzaki (*see* Evidence Appendix B). *See* the August 13, 2004, Final Office Action at pages 3-5.

(b) Claims 9, 15, 30 and 44 were rejected under 35 U.S.C. § 103(a) based on Thinesen in view of Kanzaki, and in further view of U.S. Patent No. 5,771,399 to Fishman (*see* Evidence Appendix D). *See* the August 13, 2004, Final Office Action at pages 5-6.

None of the pending claims have been allowed. Appellants appeal the final rejection of all of the pending claims in this application (*i.e.*, claims 1-51).

(vii) Argument (37 C.F.R. § 41.37(c)(1)(vii))

For the reasons described in detail below, Appellants respectfully assert that the Primary Examiner's final rejection of claims 1-51 in this application constitutes reversible error. Accordingly, the Board should reverse the final rejection. Separate sections and arguments are provided below for each ground of rejection for consideration in this Appeal.

(a) Appellants' Claims 1-8, 10-14, 16-29, 31-43, and 45-51 Patentably Distinguish from the Combination of Thinesen with Kanzaki

The Primary Examiner rejected claims 1-8, 10-14, 16-29, 31-43 and 45-51 under 35 U.S.C. § 103(a) based on Thinesen in view of Kanzaki. *See* the August 13, 2004, Final Office Action at pages 3-5. Appellants respectfully traverse this rejection, and courteously ask for its reversal.

Each of Appellants' independent claims 1, 13, 27, and 41 recites the determination of a pace by dividing a distance stored in memory by an elapsed time or a segment of an elapsed time (*e.g.*, a split time). As described in Appellants' specification, the elapsed time is a time period that has already occurred, not a predicted, future, or target time period. *See* Appellants' specification at page 4, lines 7-18; page 4, lines 23-25; page 6, lines 6-8; page 6, lines 13-17; page 7, lines 3-28; and page 10, line 3 through page 11, line 29). Appellants respectfully assert that the determination of a pace as recited in these claims is not taught or suggested by either the Thinesen patent or the Kanzaki patent.

To support a rejection for obviousness under 35 U.S.C. § 103(a), the obviousness rejection must include some articulated reasoning that makes logical sense. *See KSR Int'l Co. v. Teleflex, Inc.*, 127 S.Ct. 1727, 1741 (2007) ("To facilitate review, this analysis should be made explicit. *See In re Kahn*, 441 F.3d 977, 988 (C.A.Fed. 2006) ("[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness")."). As will be demonstrated below, because the final rejection is based on an erroneous interpretation of the cited references, the rejection fails to provide adequate "reasoning" with a sufficient "rational underpinning" to support the Office's ultimate conclusion of obviousness. The rejection should be reversed.

With regard to the Thinesen patent, this patent describes establishing a pace by actuating command buttons in synchronism with the user's footsteps. *See, e.g.*, Thinesen at column 2, lines 11-14; column 7, lines 38-41; and column 8, lines 3-10. In addition, this patent describes that the pace reflects the number of a user's steps per minute, not an actual distance traveled. *Id.*, at column 6, lines 31-58. Appellants note that the Thinesen patent does describe a technique of multiplying this type of pace by another value, in order to convert it into a unit of distance per

time. This technique, however, does not employ a stored distance and a stored elapsed time, as recited in Appellants' claims. Stated simply, the pace value determination disclosed by Thinesen differs substantially from Appellants' claimed pace calculation system and method.

The Kanzaki patent does not overcome the deficiencies of Thinesen. Kanzaki discloses determining a pace using a number of alternate techniques, but this patent still does not teach or suggest determining a pace in the manner recited in Appellants' claims. As one example, Kanzaki discloses calculating a target pace at which a user would need to move in order to travel a distance in a target time. *See*, for example, Kanzaki at column 8, lines 55-58 and column 17, lines 4-20. Thus, this type of "target" pace cannot be and is not determined based upon an elapsed time. Kanzaki also discloses setting a desired pace by keying in pace data through a key switch. *Id.*, at column 6, lines 56-57. Again, this portion of the Kanzaki patent does not teach or suggest determining a pace using an elapsed time. Still further, the Kanzaki patent discloses determining a pace by receiving signals from a pedometer. *Id.*, at column 12, line 61 to column 13, line 25. Accordingly, Appellants respectfully submit that the Kanzaki patent does not teach or suggest the pace calculation features of the invention in the manner recited in any of Appellants' claims (*e.g.*, based on a distance stored in a distance memory and an elapsed time).

The Examiner has specifically noted that the Kanzaki patent discloses the general formula for calculating pace as:

$$p = d \div w \div t.$$

See, for example, Kanzaki at column 1, line 40 and the August 13, 2004, Final Office Action at page 7, lines 3-7. Appellants respectfully point out, however, that the Kanzaki patent describes using this formula to determine a desired pace based upon a target run time t. *See* Kanzaki at column 1, line 34. This portion of Kanzaki does not teach or suggest using an elapsed time to determine an actual pace, as recited in Appellants' claims.

Accordingly, Appellants respectfully submit that the combined teachings of Thinesen and Kanzaki fail to disclose all of the recited features of Appellants' claimed invention. The final rejection of claims 1, 13, 27, and 41 (as well as their associated dependent claims) should be reversed due to this deficiency.

Moreover, Appellants respectfully assert that the final rejection fails to provide a rational basis for concluding that the claimed invention would have been obvious to a person having ordinary skill in the art because the cited art relates to very different pace related concepts. The Kanzaki patent is directed to determining a desired pace for someone to run. The Thinesen patent, on the other hand, is directed to a device for synchronizing a pace produced by the device with the user's actual pace. Thus, in addition to not teaching the features of the invention, combining the features of the Thinesen patent with those described in the Kanzaki patent in the manner suggested by the Primary Examiner would vitiate the very teachings and purpose of the device of the Thinesen patent. Appellants respectfully assert that there is no rational reasoning to support modifying the teachings of a reference in a manner that eliminates the very purpose of the device according to the reference.

Furthermore, Appellants respectfully assert that the rejection fails to provide a rational basis for concluding that the claimed invention is obvious because the rejection is based on a misunderstanding of the cited Thinesen and Kanzaki patents. For example, in the June 30, 2005, Examiner's Answer, the Primary Examiner stated:

> Kanzaki teaches determining a pace by initiating a stop watch, timing the duration of time that it takes for a runner to run a distance X and setting the pace therefrom, see Kanzaki column 6, line 53 - column 7, line 8.

See the June 30, 2005, Examiner's Answer at page 7, lines 15-17. To demonstrate how the Primary Examiner has misinterpreted the Kanzaki and Thinesen patents, this portion of the Kanzaki patent is reproduced in its entirety below:

> In the test run mode, a pace in the first mode test run is set and a test run time in which the runner runs any distance x at the pace is measured (step A3).
>
> The ***runner keys in pace data*** by the fourth key switch S4 to set the pace. As shown in the first test run picture B of FIG. 3, ***the pace is set, for example, at 190 steps/minute***. The pace data P1 is stored in the first pace P1 memory area 5e of the RAM 5 of FIG. 2. The CPU 3 outputs a pace signal to the amplifier 6 on the basis of the pace data and the speaker 7 generates a signal sound at periods of 190 steps/minute.
>
> As shown in FIG. 5, the runner runs a course X having any distance x ***at a pace corresponding to the signal sound***. At the start of the course X, the runner depresses the fifth key switch S5 to start the stopwatch function and starts to run the course to the signal sound. The runner then stops the stopwatch function by depression of the fifth key switch S5 again at the end point of the course X to

> measure the test run time for the course X. The test run time data obtained in this measurement is stored in the first test run time T1 area 5f of the RAM 5. Assume now that the first run time taken is 21 seconds.

See Kanzaki at column 6, line 53 - column 7, line 8 (***emphasis added***). If it shows nothing else, the emphasized language from this Kanzaki excerpt clearly establishes that this portion of the Kanzaki patent does not teach or suggest determining a pace, as argued by the Primary Examiner.

Instead, this portion of the Kanzaki patent specifically describes having the user enter a predetermined pace. A CPU then outputs a signal corresponding to the pace *input by the user*. Thus, if the user inputs a pace of 2 mph, this is the pace information stored in the Kanzaki system, regardless of the actual pace, faster or slower, subsequently run by the user. While the Kanzaki patent does teach calculating a pace, it does not do so in the text relied upon by the Primary Examiner. Moreover, Kanzaki's methods of calculating a pace, as described above, do not teach or suggest the method and devices recited in Appellants' claims.

For the foregoing reasons, Appellants respectfully submit that the final rejection fails to demonstrate that the claimed invention is *prima facie* obvious. There is no rational reasoning for modifying the references in the manner suggested by the Examiner because the asserted and underlying reasoning and motivation are based on a misinterpretation of the cited Thinesen and Kanzaki patents. Moreover, even if combined, these patents fail to disclose or reasonably suggest the pace calculation features of the invention as recited in independent claims 1, 13, 27, and 41. The final rejection of claims 1-8, 10-14, 16-29, 31-43 and 45-51 should be reversed.

(b) Appellants' Claims 9, 15, 30, and 44 Patentably Distinguish from the Combination of Thinesen with Kanzaki and Fishman

The Primary Examiner also finally rejected claims 9, 15, 30 and 44 based on the combination of the Thinesen and Kanzaki patents, in further view of U.S. Patent No. 5,771,399 to Fishman. *See* the August 13, 2004, Final Office Action at 5-6. Appellants respectfully traverse this rejection, and courteously ask for its reversal.

Claims 9, 15, 30, and 44 depend from claims 1, 13, 27, and 41, respectively. As explained in detail above, there is no rational reasoning for modifying the teachings of Thinesen and/or Kanzaki to arrive at Appellants' claimed invention as recited in claims 1, 13, 27, and 41.

Further, the combination of Thinesen with Kanzaki does not teach or suggest the invention as recited in any of claims 1, 13, 27, and 41. Appellants respectfully assert that the Fishman patent does not remedy the deficiencies of the Thinesen and Kanzaki patents, and Fishman does provide any rational reasoning for modifying the teachings of Thinesen and/or Kanzaki to arrive at Appellants' claimed invention. Appellants therefore ask that the rejection of claims 9, 15, 30, and 44 be reversed as well.

Conclusion

The August 13, 2004, Final Office Action fails to carry the Office's burden of establishing that the claimed invention is rendered *prima facie* obvious by the cited patents. The cited patents simply fail to teach or suggest calculation of a pace, using an actual elapsed time period and a stored distance, in the manner recited in Appellants' claims. Thus, the final rejections of claims 1-51 should be reversed. Appellants respectfully solicit reversal of these rejections.

In accordance with 37 C.F.R. § 41.31 Appellants submit this Appeal Brief to the Board of Patent Appeals and Interferences. Because the Appeal Brief Fee has previously been submitted, Appellants respectfully assert that no additional fee is due at this time. If, however, any fees are due to facilitate entry and consideration of this Appeal Brief and to maintain the pendency of this application, the Commissioner is authorized to charge any necessary fees to the Deposit Account of the undersigned, Deposit Account No. 19-0733.

Respectfully submitted,

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Dated: August 17, 2007

Claims Appendix (37 C.F.R. § 41.37(c)(1)(viii))
Claims Involved in the Appeal

Claims Appendix (37 C.F.R. § 41.37(c)(1)(viii))
Claims Involved in the Appeal

This Appendix includes a clean copy of claims 1-51, the claims involved in this Appeal:

1. A device for calculating a pace, comprising:

a chronograph for measuring an elapsed time;

a distance memory containing a distance; and

a pace calculation process which calculates the pace by dividing the distance contained in the distance memory by the elapsed time provided by the chronograph.

2. The device recited in claim 1, further comprising a display which displays the calculated pace.

3. The device recited in claim 1, further comprising a chronometer.

4. The device recited in claim 1, further comprising an input device that allows a user to input the distance into the distance memory.

5. The device recited in claim 4, wherein the input device includes at least one depressable button.

6. The device recited in claim 5, wherein the input device includes a first depressable button for selecting a data field, a second depressable button for incrementing a value in a selected data field, and a third depressable button for decrementing the value in the selected data field.

7. The device recited in claim 1, wherein the chronograph is implemented using a mechanical structure.

8. The device recited in claim 7, further including an optical encoder for converting an elapsed time measured by the chronograph into a digital format.

9. The device recited in claim 1, wherein the chronograph, the distance memory, and the pace calculation process are incorporated into a personal digital assistant.

10. The device recited in claim 1, wherein the chronograph, the distance memory, and the pace calculation process are incorporated into a watch.

11. The device recited in claim 10, wherein the watch is a wristwatch.

12. The device recited in claim 1, further including a data memory for storing the calculated pace.

13. A method of calculating a pace with a pace calculation device, comprising:

receiving a distance into a distance memory of a pace calculation device;

measuring an elapsed time with a chronograph; and

dividing the distance contained in the distance memory by the elapsed time provided by the chronograph to calculate a pace.

14. The method recited in claim 13, further comprising displaying the calculated pace to a user of the pace calculation device.

15. The method recited in claim 13, further comprising providing the calculated pace to another device.

16. The method recited in claim 13, wherein receiving the distance into the distance memory includes:

receiving input selecting a numerical value; and

receiving input selecting a distance unit from among a plurality of distance units.

17. The method recited in claim 16, wherein the plurality of distance units include two or more selected from the group consisting of kilometers, miles, yards, meters, feet, and nautical miles.

18. The method of claim 13, further comprising:

measuring a second elapsed time with the chronograph that is a segment of a larger elapsed time measured by the chronograph;

determining a portion of the distance corresponding to the second elapsed time; and

calculating a pace for the portion of the distance.

19. The method recited in claim 13, further comprising:

measuring a plurality of split times with the chronograph, each split time being a segment of the elapsed time;

determining the number of measured split times;

dividing the distance by the determined number of measured split times to obtain a segment distance; and

dividing the segment distance by at least one of the measured split times to calculate a pace corresponding to the at least one of the measured split times.

20. The method recited in claim 19, further comprising dividing the segment distance by each of the measured split times to calculate a pace corresponding to each of the measured split times.

21. The method recited in claim 13, wherein the distance is received into the distance memory from an input device having at least one depressable button.

22. The method recited in claim 21, further comprising detecting actuation of a first depressable button of the input device for selecting a data field, detecting actuation of a second depressable button of the input device for incrementing a value in a selected data field, and detecting actuation of a third depressable button of the input device for decrementing the value in the selected data field.

23. The method recited in claim 1, further comprising receiving the distance into the distance memory before measuring the elapsed time.

24. The method recited in claim 1, further comprising receiving the distance into the distance memory after measuring the elapsed time.

25. The method recited in claim 1, further comprising receiving the distance into the distance memory while measuring the elapsed time.

26. The method recited in claim 1, further comprising saving the calculated pace into a data memory.

27. A method of calculating a pace, comprising:

inputting a distance into a distance memory of a pace calculation device;

prompting the pace calculation device to measure an elapsed time; and

prompting the pace calculation device to calculate a pace by dividing the distance by the elapsed time.

28. The method recited in claim 27, wherein inputting the distance into the distance memory prompts the pace calculation device to calculate the pace.

29. The method recited in claim 27, further comprising prompting the pace calculation device to display the calculated pace.

30. The method recited in claim 27, further comprising prompting the pace calculation device to provide the calculated pace to another device.

31. The method recited in claim 27, wherein inputting the distance into the distance memory includes:

selecting a numerical value; and

selecting a distance unit from among a plurality of distance units.

32. The method recited in claim 31, wherein the plurality of distance units include two or more selected from the group consisting of kilometers, miles, yards, meters, feet, and nautical miles.

33. The method of claim 27, further comprising:

prompting the pace calculation device to measure a second elapsed time that is a segment of a larger elapsed time; and

prompting the pace calculation device to

determine a portion of the distance corresponding to the second elapsed time; and

calculate a pace for the portion of the distance.

34. The method recited in claim 27, further comprising:

prompting the pace calculation device to measure a plurality of split times with the chronograph, each split time being a segment of the elapsed time; and

prompting the pace calculation device to

determine the number of measured split times;

divide the distance by the determined number of measured split times to obtain a segment distance; and

divide the segment distance by at least one of the measured split times to calculate a pace corresponding to the at least one of the measured split times.

35. The method recited in claim 34, further comprising prompting the pace calculation device to divide the segment distance by each of the measured split times to calculate a pace corresponding to each of the measured split times.

36. The method recited in claim 27, further comprising inputting the distance into the distance memory using an input device having at least one depressable button.

37. The method recited in claim 36, further comprising

actuating a first depressable button of the input device to select a data field,

actuating a second depressable button of the input device to incrementing a value in the selected data field, and

actuating a third depressable button of the input device to decrement the value in the selected data field.

38. The method recited in claim 27, further comprising inputting the distance into the distance memory before prompting the pace calculation device to measure the elapsed time.

39. The method recited in claim 27, further comprising inputting the distance into the distance memory after prompting the pace calculation device to measure the elapsed time.

40. The method recited in claim 27, further comprising inputting the distance into the distance memory while the pace calculation device is measuring the elapsed time.

41. A method of calculating a pace with a pace calculation device, comprising:

receiving a distance into a distance memory of a pace calculation device;

measuring a plurality of split times with the pace calculation device, each split time being a segment of a total elapsed time;

determining the number of measured split times;

dividing the distance by the determined number of measured split times to obtain a segment distance; and

dividing the segment distance by at least one of the measured split times to calculate a pace corresponding to the at least one of the measured split times.

42. The method recited in claim 41, further comprising dividing the segment distance by each of the measured split times to calculate a pace corresponding to each of the measured split times.

43. The method recited in claim 41, further comprising displaying the calculated pace to a user of the pace calculation device.

44. The method recited in claim 41, further comprising providing the calculated pace to another device.

45. The method recited in claim 41, wherein receiving the distance into the distance memory includes:

receiving input selecting a numerical value; and

receiving input selecting a distance unit from among a plurality of distance units.

46. The method recited in claim 45, wherein the plurality of distance units include two or more selected from the group consisting of kilometers, miles, yards, meters, feet, and nautical miles.

47. The method recited in claim 41, wherein the distance is received into the distance memory from an input device having at least one depressable button.

48. The method recited in claim 47, further comprising detecting actuation of a first depressable button of the input device for selecting a data field, detecting actuation of a second depressable button of the input device for incrementing a value in a selected data field, and detecting actuation of a third depressable button of the input device for decrementing the value in the selected data field.

49. The method recited in claim 41, further comprising receiving the distance into the distance memory before measuring the split times.

50. The method recited in claim 41, further comprising receiving the distance into the distance memory after measuring the split times.

51. The method recited in claim 41, further comprising saving the calculated pace into a data memory.

Evidence Appendix A (37 C.F.R. § 41.37(c)(1)(ix))
U.S. Patent No. 5,050,141 to Thinesen

This patent was originally made of record and relied upon by the Office in the First Office Action mailed February 20, 2004.

United States Patent [19]

Thinesen

[11] Patent Number: 5,050,141

[45] Date of Patent: Sep. 17, 1991

[54] **PROGRAM TO SYNCHRONIZE PACE IN A MULTIMODE ALARM TIMEPIECE**

[75] Inventor: **Tom Thinesen**, Sunnyvale, Calif.

[73] Assignee: **Timex Corporation**, Middlebury, Conn.

[21] Appl. No.: **559,770**

[22] Filed: **Jul. 30, 1990**

[51] **Int. Cl.**[5] **G04B 23/02**; G04F 8/00; G01C 22/00

[52] **U.S. Cl.** **368/73**; 368/109; 368/110; 368/251; 364/565; 364/569; 377/20

[58] **Field of Search** .... 368/10, 72–74, 368/107–113, 250–251; 364/410, 413.02, 561, 569; 340/309.15, 309.4, 384 E; 377/15, 20

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4,632,570	12/1986	Kelsey	368/107
4,887,249	12/1989	Thinesen	368/10

OTHER PUBLICATIONS

Casio Model Nos. J-31N-1; J-51W-1B; JP-10-0W-1BV; EXW-50-IAV from "Casio Collection 1990", pp. 5, 6.

47st Photo Ad p. 97, 1990 Catalog—Casio Runners Watch, Model J52W.

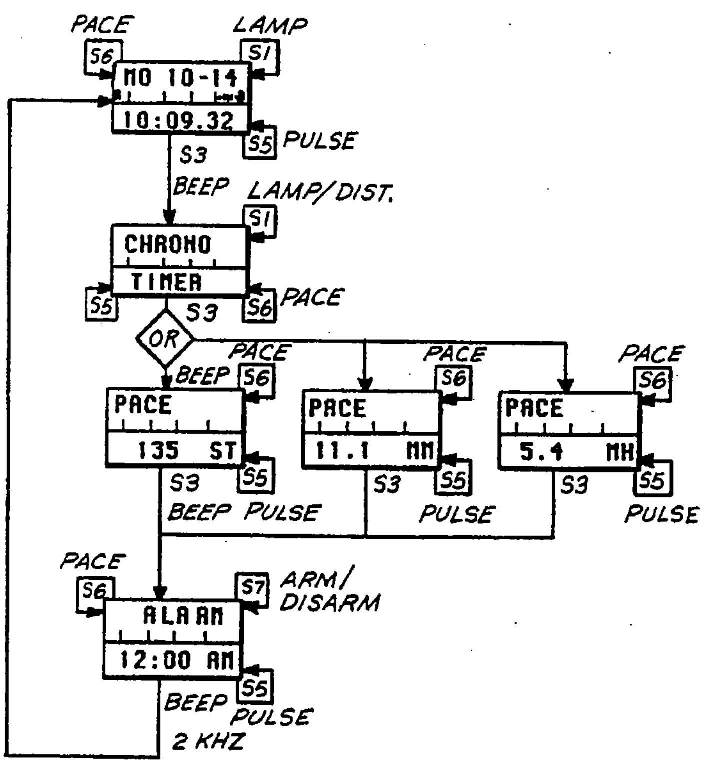
Primary Examiner—Vit W. Miska

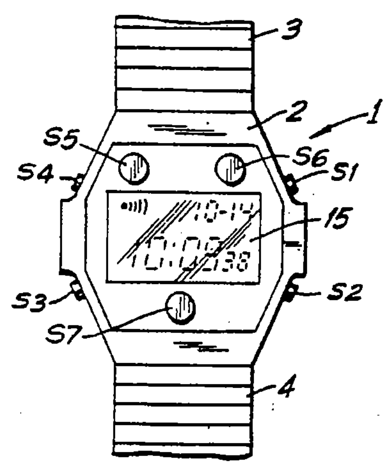
Attorney, Agent, or Firm—William C. Crutcher

[57] **ABSTRACT**

A multimode electronic timepiece has an electroptic display, an alarm, several pushbuttons and an integrated circuit programmed to keep time. Several timepiece operating modes include a pace mode, wherein audible periodic beeping sounds are produced by the alarm which correspond to the value of a preselected pace of an operator. A first manual actuation of a pushbutton commences a timing event, and second manual actuation of the pushbutton terminates the timing event. An internal program alters the preselected pace and stores an altered pace in response to the time elapsed between first and second actuation of the pushbutton. The program displays the altered pace and causes the alarm to beep at a rate equivalent to the altered pace.

17 Claims, 5 Drawing Sheets





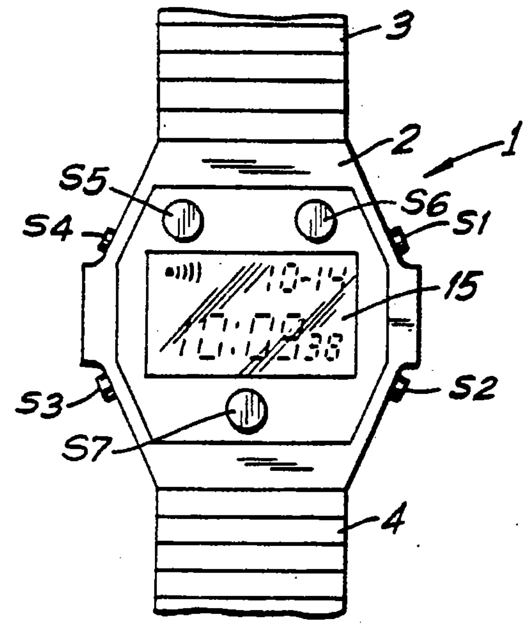

3
2
1
S5
S6
S4
S1
15
S3
S2
S7
4

FIG.1

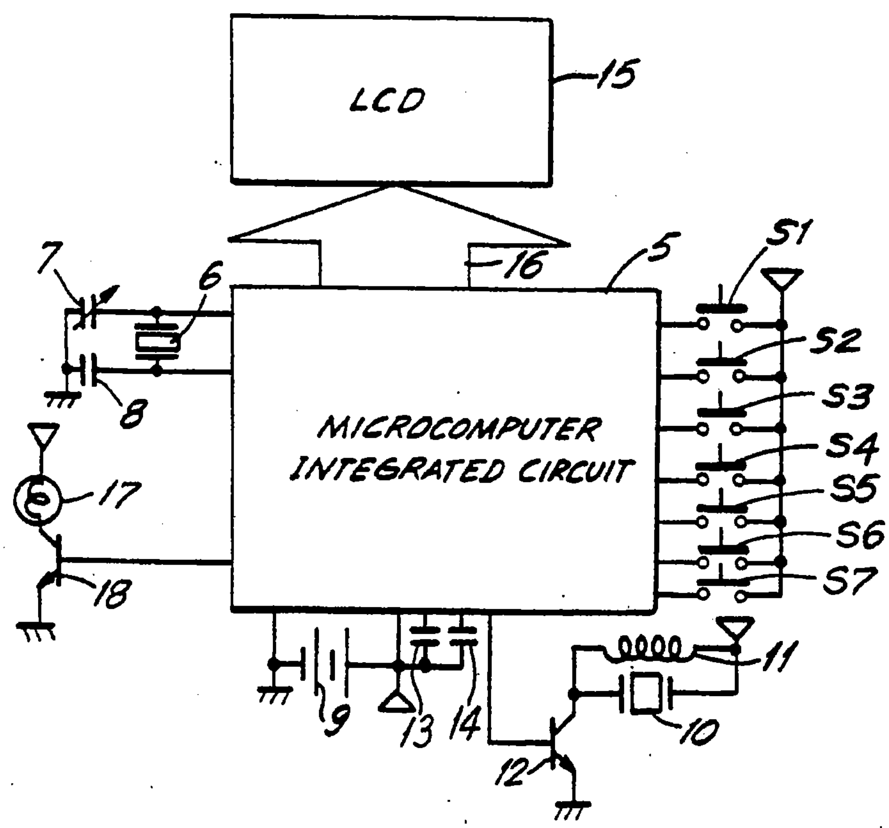

LCD
15
7
6
16
5
S1
S2
8
S3
MICROCOMPUTER
INTEGRATED CIRCUIT
S4
S5
17
S6
S7
18
11
9
13
14
10
12

FIG.2

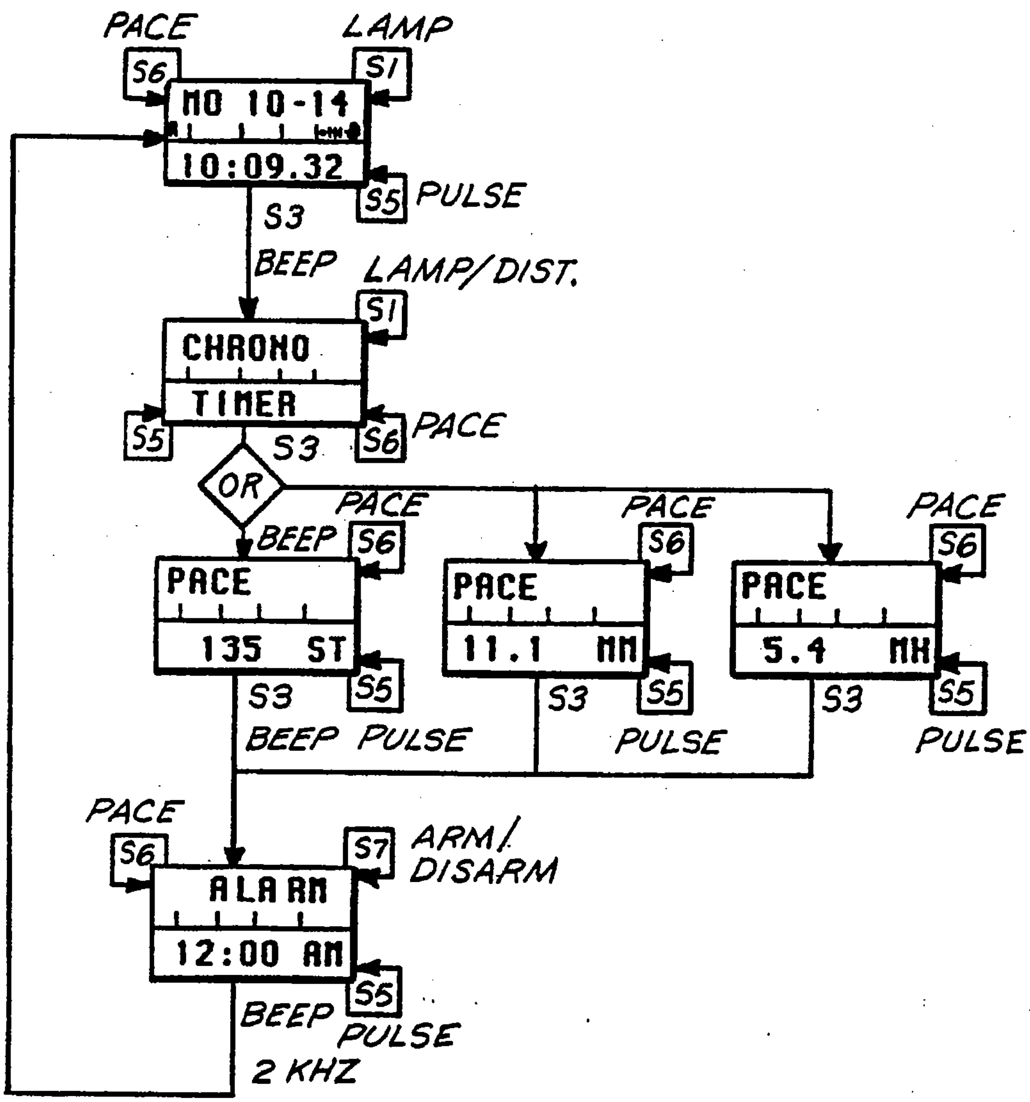

PACE
LAMP
S6
S1
MO 10-14
10:09.32
S5
PULSE
S3
BEEP
LAMP/DIST.
S1
CHRONO
TIMER
S5
S6
PACE
S3
OR
BEEP
PACE
S6
PACE
135 ST
S5
PACE
S6
PACE
11.1 MM
S5
PACE
S6
PACE
5.4 MH
S5
S3
BEEP PULSE
S3
PULSE
S3
PULSE
PACE
S6
S7
ARM/
DISARM
ALARM
12:00 AM
S5
BEEP
PULSE
2 KHZ

FIG.3

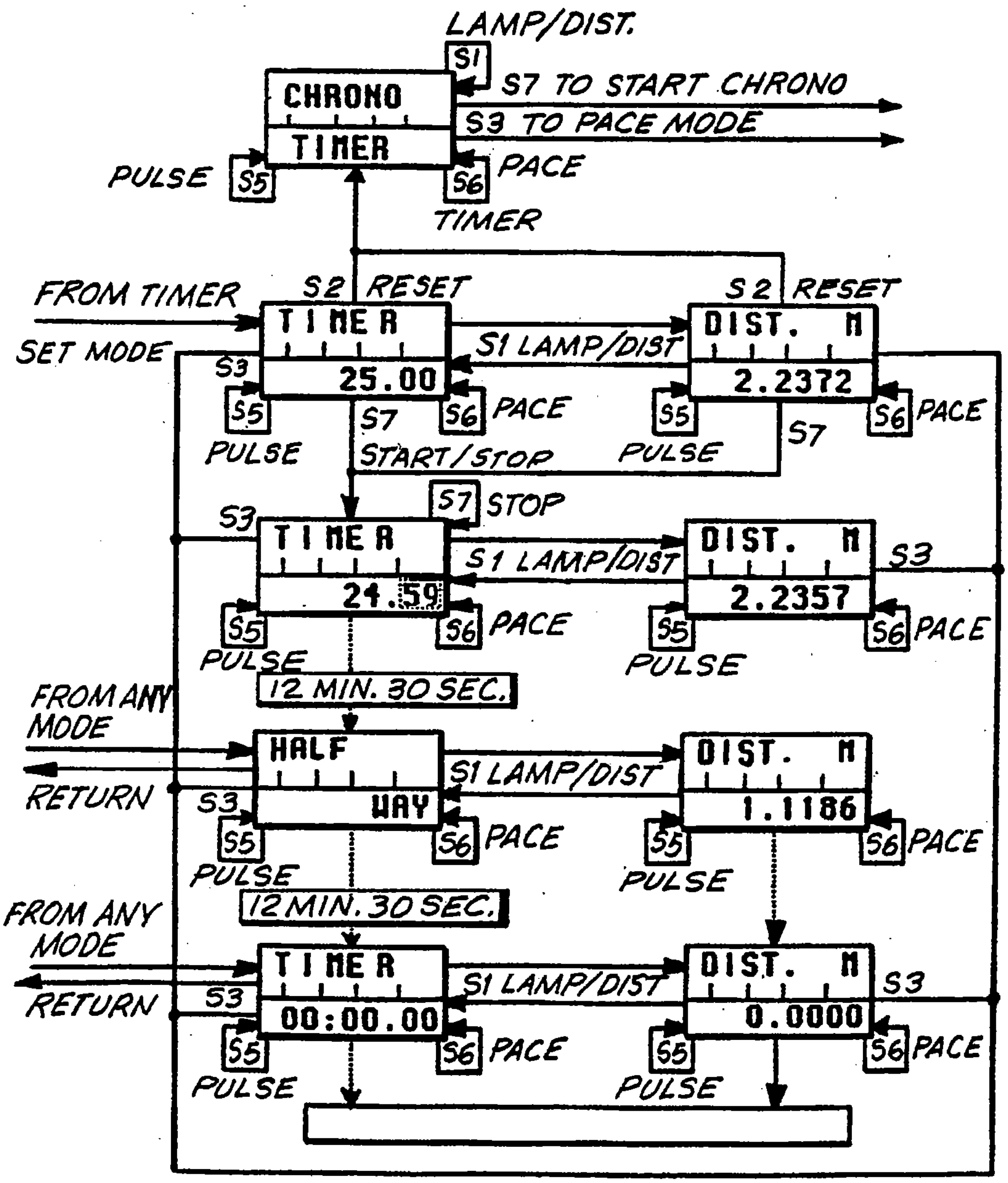

LAMP/DIST.
S1
CHRONO
TIMER
S7 TO START CHRONO
S3 TO PACE MODE
PULSE
S5
S6
PACE
TIMER
FROM TIMER
SET MODE
S2 RESET
S2 RESET
TIMER
25.00
S3
S1 LAMP/DIST
DIST. M
2.2372
S5
S6
PACE
PULSE
S7
START/STOP
S7 STOP
TIMER
24.59
S1 LAMP/DIST
DIST. M
2.2357
S3
12 MIN. 30 SEC.
FROM ANY MODE
RETURN
HALF
WAY
S1 LAMP/DIST
DIST. M
1.1186
12 MIN. 30 SEC.
FROM ANY MODE
RETURN
TIMER
00:00.00
S1 LAMP/DIST
DIST. M
0.0000

FIG. 4

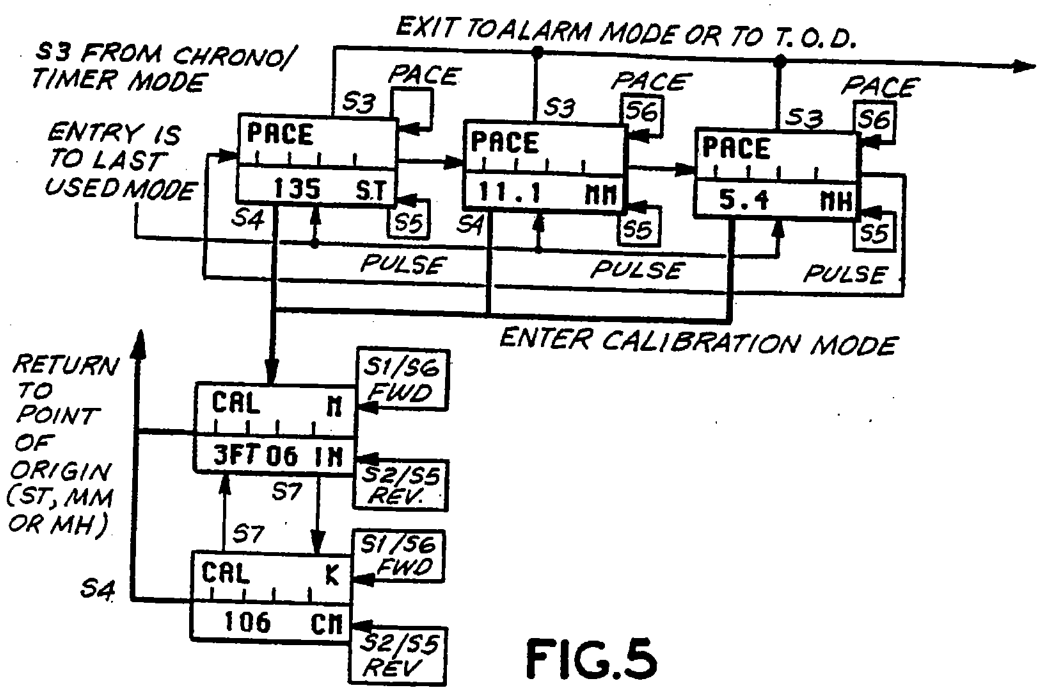

EXIT TO ALARM MODE OR TO T.O.D.
S3 FROM CHRONO/TIMER MODE
ENTRY IS TO LAST USED MODE
PACE
S3
PACE 135 ST
S4
S5
PULSE
PACE
S6
S3
PACE 11.1 MM
S4
S5
PULSE
PACE
S6
S3
PACE 5.4 MH
S5
PULSE
ENTER CALIBRATION MODE
RETURN TO POINT OF ORIGIN (ST, MM OR MH)
CAL M
3FT 06 IN
S1/S6 FWD
S2/S5 REV.
S7
S7
CAL K
106 CM
S1/S6 FWD
S2/S5 REV
S4

FIG.5

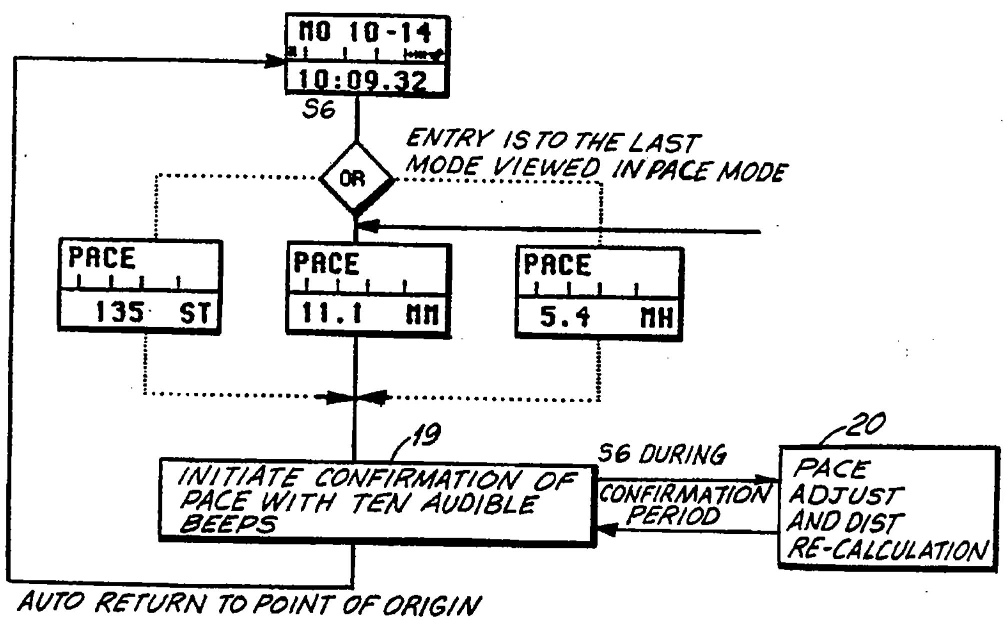

MO 10-14
10:09.32
S6
ENTRY IS TO THE LAST MODE VIEWED IN PACE MODE
OR
PACE 135 ST
PACE 11.1 MM
PACE 5.4 MH
19
INITIATE CONFIRMATION OF PACE WITH TEN AUDIBLE BEEPS
S6 DURING
CONFIRMATION PERIOD
20
PACE ADJUST AND DIST RE-CALCULATION
AUTO RETURN TO POINT OF ORIGIN

FIG.6

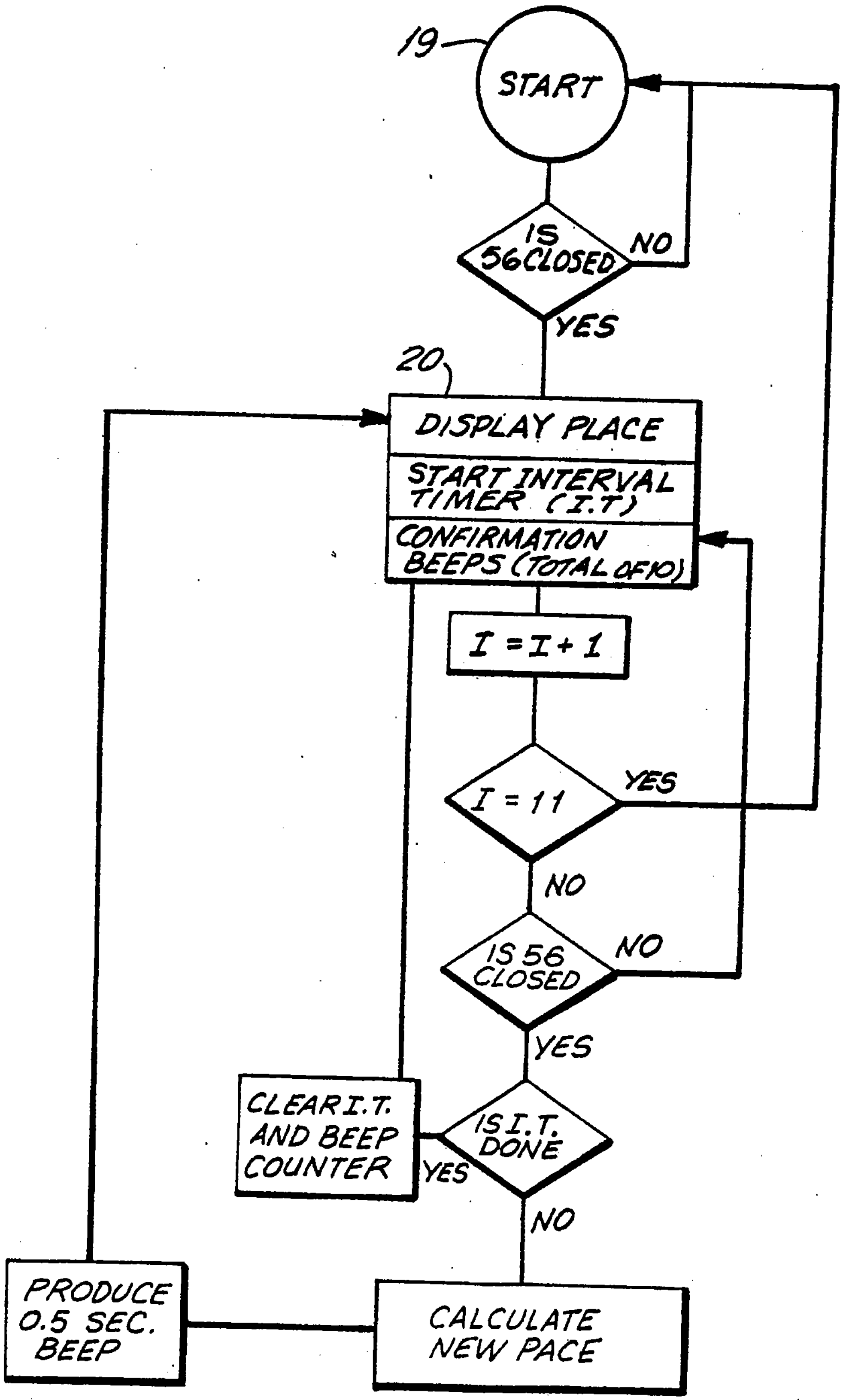

19
START
IS 56 CLOSED
NO
YES
20
DISPLAY PLACE
START INTERVAL TIMER (I.T)
CONFIRMATION BEEPS (TOTAL OF 10)
I = I + 1
I = 11
YES
NO
IS 56 CLOSED
NO
YES
IS I.T. DONE
YES
CLEAR I.T. AND BEEP COUNTER
NO
CALCULATE NEW PACE
PRODUCE 0.5 SEC. BEEP

FIG.7

PROGRAM TO SYNCHRONIZE PACE IN A MULTIMODE ALARM TIMEPIECE

BACKGROUND OF THE INVENTION

This invention relates generally to multimode electronic timepieces which display and sound walking or running pace with audible alarm devices. More particularly, the invention relates to an improved program for altering a previously selected pace and for performing calculations utilizing the altered pace. Such electronic timepieces are used by runners, walkers, bicyclists, rowers and the like.

Multimode, multifunction wristwatches (or wrist instruments) are known which include a display, an audible alarm device or beeper, a number of manually actuated switches and an integrated circuit programmed in a preselected sequence. Examples of such watches are seen in U.S. Pat. Nos. 4,783,773—Houlihan et al, 4,780,864—Houlihan and U.S. Pat. No. 4,283,784—Horan, all of the foregoing being assigned to the present assignee. In the foregoing patents, which are merely exemplary of multimode electronic wrist instruments or multifunction wristwatches, one of the manual actuators may typically serve to repetitively cycle the instrument through a number of modes or operating states in each of which a different type of information is displayed. Such modes may include, in a multifunction watch, the time of day, chronograph, dual time zone, elapsed time and an alarm setting mode. By special actuation of one of the preselected switches, the wristwatch may be further converted into a computer, a speedometer, pulsometer or any other type of device which will perform calculations and display data, subject only to the imagination of the designer and programmer of the integrated circuit. While in any of these modes, one or more manual switch actuators may be employed to enter information or to perform calculations. One such application, and one to which the present invention applies, is a pace counting watch, which counts and selectively beeps to provide a running pace, a walking pace, a cycling cadence and so forth.

Information from external sources other than the operator may also be entered into the wrist instrument, and if this instrument includes a sensor which is capable of detecting an operating condition said information may be entered automatically, without manipulation by the operator. Calculations involving speed and rate and other time variable information can be performed in order to display useful information by using the time keeping circuit as a clock. For example, in U.S. Pat. No. 4,887,249, issued Dec. 12, 1989 and assigned to the present assignee, a bicycle watch is disclosed which is converted into an odometer or speedometer. One input to the odometer formula is bicycle wheel diameter, which is manually entered by the operator, and another is revolutions per minute (rpm) of the bicycle wheel. The latter (rpm) is detected by a sensor, so that as the operator speeds up or slows down, the rpm information supplied for the calculation is constantly readjusted and so, therefore, is the information displayed.

Pacer or walker watches are known which provide rhythmic beeps, the rate of which is preset by the operator, and which are used to establish a walking or running pace. When this preselected pace or cadence "counting rate" usually expressed in steps per minute is entered together with a preselected "stride" distance, the watch will calculate the distance covered by the walker or runner, his rate of travel, and the remaining distance to be traveled. Thus, the walker or runner must conform this pace to the cadence which he has set ahead of time. However, this preset cadence might not be comfortable, or might vary from the natural cadence of the runner or walker, and therefore he might desire to change this cadence. Although the cadence may be changed, this is a cumbersome process which may require several adjustments and will also likely require the walker or runner to stop in order to reset the cadence.

Accordingly, one object of the present inventions is to provide an improved program which will allow the operator to synchronize the pace which is set in a multimode alarm timepiece with the operator's natural pace.

Another object of the invention is to provide an improved program to perform calculations in multimode timepiece which will permit correction of the pace in accordance with feedback information entered by the operator, revise the calculations using this corrected pace, and then display the results of the revised calculations.

Another object of the invention is to provide an improved program in a multimode timepiece which will allow a runner or walker to alter and synchronize the pace provided by the timepiece in a simple manner while running or walking.

SUMMARY OF THE INVENTION

Briefly stated, the invention comprises an improvement in a multimode electronic timepiece having an electroptic display, an audible device, several manually actuated actuators and a mask programmable integrated circuit programmed to keep time and to provide several timepiece operating modes. The modes include a pace mode, wherein said integrated circuit is programmed to permit an operator to switch between modes in response to actuation of at least a first of said actuators. The integrated circuit is further programmed to accept and store information in memory in response to actuation of at least a second of said actuators, to perform calculations thereon and to display said information and results of said calculations on said electroptic display. The integrated circuit is further programmed to provide, upon actuation of at least a third of said actuators, audible periodic electronic sounds produced by said audible device, wherein the frequency of said sounds varies proportionately to the value of a preselected pace of said operator. The improvement comprises means responsive to first manual actuation of a selected actuator coinciding with one footfall of the operator to commence a timing event, means responsive to second manual actuation of said selected actuator coinciding with a later footfall of the operator to terminate said timing event, program means to alter said preselected pace and store an altered pace which is inversely proportional to the time elapsed between first and second actuation of said selected actuator, and means for displaying said altered pace and causing said audible device to sound at a rate equivalent to said altered pace.

DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the

following description, taken in connection with the accompanying drawing, in which:

FIG. 1 is a plan view of a multimode electronic wristwatch in simplified form;

FIG. 2 is a block diagram of a circuit for the wristwatch of FIG. 1, together with external components such as audible device, switches and display;

FIG. 3 is a block diagram of a multimode wristwatch illustrating the basic sequence of modes which are displayed in response to manually actuated switches;

FIG. 4 is a detailed state diagram of an elapsed time mode with means to also display distance to be traveled during this elapsed time;

FIG. 5 is a detailed state diagram explaining operation of the pace display selection and stride calibration mode;

FIG. 6 is a general state diagram showing audible pace confirmation and pace adjustment; and

FIG. 7 is a detailed flow chart explaining operation of the audible pace confirmation and pace adjustment program.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the drawing, a multimode electronic wristwatch 1 includes a case 2 adapted to be held on the wrist by a strap, portions of which are seen at 3 and 4. The wristwatch case includes seven manual pushbutton actuators S1, S2, S3, S4, S5, S6, and S7 arranged to close spring contacts (not shown) inside the watch case 2. An electroptic display 15, which is commonly a liquid crystal display (or LCD) displays digits, letters or other symbols when activated by a microcomputer inside the watch in the form of an integrated circuit.

Referring to FIG. 2 of the drawing, a schematic block diagram of the electrical connections is shown which is in accordance with conventional multimode electronic watch technology well known to those skilled in the art. A programmable microcomputer 5, in the form of a mask-programmable integrated circuit is bonded to a printed circuit board (not shown) and includes suitable pin connections and leads connected to various external components shown in the diagram which are also mounted on the printed circuit board. The microcomputer includes a microprocessor, operating system program for carrying out instructions, and addressable ROM and RAM memory locations. A quartz crystal 6 connected in circuit with capacitors 7 and 8 and connected to the oscillator pins of the integrated circuit 5 provides a high-frequency time base. A battery power source 9 is provided in the form of a button type energy cell in the watch case. An audible sounding device serving as beeper and watch alarm is made up of a piezoelectric crystal 10, inductance coil 11 and drive transistor 12. Two fixed external capacitors 13, 14 combined with other circuit elements inside the integrated circuit 5 serve to boost the output voltage to drive LCD 15 through a display bus 16, which depicts multiple leads connected to the various actuatable segments of the LCD display 15 (also shown in FIG. 1). Display 15 optionally may be arranged in close proximity with, so as to be illuminated by, a lamp 17 when the lamp is lit by a switching signal from integrated circuit 5 applied to the base of switching transistor 18.

The following Table 1 shows a complete list of modes for time-of-day mode (TOD), chronograph mode (CHRONO), elapsed time mode (TIMER), pace mode (PACE) and alarm mode (ALARM). Column 1 identifies the manually actuated switches S1 through S7 and columns 2 through 6 show the action taken when the switch is actuated while in that particular mode. Column 7 (SET) is a setting routine which is entered from selected modes by pressing a selected actuator, S4, as shown in columns 2, 4 and 6 of Table 1. Once in the SET routine, switches S1 through S7 perform the indicated task shown in Column 7. The switch S6 initiates the pace confirmation and pace adjustment program from any of the display modes of columns 2 through 6.

TABLE 1

Col. 1 SWITCH	Col. 2 T.O.D.	Col. 3 CHRONO	Col. 4 TIMER	Col. 5 PACE	Col. 6 ALARM	Col. 7 SET
S1	LAMP	LAMP/DIST	LAMP/DIST	LAMP	LAMP	FWD
S2	PEEK ALARM	STOP/RESET	RESET	PEEK T.O.D.	PEEK T.O.D.	REV
S3	MODE TO CHR/TMR	MODE TO PACE	MODE TO PACE	MODE TO ALARM	MODE TO T.O.D.	SELECT
S4	ENTER SET	SELECT LAP/SPLIT	ENTER SET	ENTER CALIB.	ENTER SET	EXIT SET
S5	PULSE CHECK	PULSE CHECK	PULSE CHECK	PULSE CHECK	PULSE CHECK	REV
S6	PACE ADJST.	PACE ADJST.	PACE ADJST.	PACE ADJST.	PACE ADJST.	FWD
S7	PEEK AT CHRONO	START/ LAP/SPLIT	START/ STOP	SELECT PACE MODE	ARM/ DISARM AL/CHI	SELECT

Referring now to FIG. 3 of the drawing, a block diagram of a multimode wristwatch illustrates the sequence of modes or states displayed in response to manually actuating switches S1–S7 in accordance with Table 1. Each of the rectangles illustrates the appearance of the display when entering the particular mode illustrated. The decision block labeled "OR" represents optional alternate display choices for the "pace" mode display a will be explained.

In FIGS. 4 through 6 of the drawing, "state" diagrams are shown for elapsed time mode, stride calibration mode and pace adjustment mode, respectively. One of the rectangles in each figure illustrates the type of display shown on the electroptic display 15 when the instrument is in that state. The other rectangles in the figure represent various states in which corrections or changes of displayed information may be controlled by the operator. The instrument continues to operate under control of the particular subroutine of the program in the microcomputer chip until the instrument is placed into another state. Manipulation of the electronic wristwatch to illuminate the display and carry out the various functions and capabilities is by selective actuation of

the manually actuated switches S1-S7. The well known programming technique for determining whether the switches are opened or closed and taking appropriate action is through the operating system computer program stored in the microcomputer memory, in which each switch condition is tested during each complete interrogation cycle in a loop. If any switch is closed, the program branches to a subroutine which initiates a counter. The counter determines how long the switch has been closed or, if the watch has entered another "state" how long it has been in that "state".

FIG. 4 illustrates the detailed operation of the instrument while in the elapsed time mode. This mode enables the operator to display through the manual actuation of switches S1-S7, elapsed time as well as distance to be traveled. The latter is dependent on the particular set time and on the current set pace and stride length, and its setting is described below.

Specifically, the elapsed mode subroutine is designed to allow the operator to set the elapsed time in one minute increments to any predetermined length of time, not exceeding 23 hours, 59 minutes and 59 seconds. The operator may do so by actuating manual actuator, S4, which will place the timepiece in set mode, setting the desired elapsed time (Col. 7) by advancing the digits (actuator S1 or S6) or decrementing the digits (S2 or S5), and then reentering the elapsed time mode by pressing actuator S4 again. Entry from the timer set mode is shown in the upper left hand corner of FIG. 4.

FIG. 4 illustrates the operation of the elapsed time mode. Upon actuation of a manual switch S7, the elapsed time subroutine is programmed to begin a "countdown" starting from said predetermined length of time and continuing until reading 0 hours, 0 minutes and 0 seconds (which will be displayed on electroptic display 15 as "00:00.00"). Manual actuation of S7 a second time will stop the "countdown" sequence, and subsequent repeated actuation of S7 will ultimately start and stop this "countdown." When the timer is stopped during the "countdown" sequence, the operator may actuate actuator S2 one time to display last set time, or two times to display "Chrono/Timer" (FIG. 4), and the distance left to be traveled.

If the timer "countdown" sequence has been initiated and one half of the preset time has elapsed, the program is designed so that the display 15 will show "HALF WAY" (FIG. 4) and, if armed, an alarm consisting of three long beeps will sound to inform the operator that one half of the preset time has elapsed. This occurs irrespective of which mode the instrument is currently in. Thus even if the instrument is in a mode other than elapsed time mode, the "HALF WAY" display will appear automatically at the appropriate time. Should the operator at this point desire to alter the mode, he may do so by manual actuation of the appropriate switches as per Table 1.

If the "countdown" sequence is permitted to continue, when the time reaches zero a ten second alarm will sound and the electroptic display 15 will show "00:00.00", again irrespective of what mode the watch was in when "zero" time was reached. Manual actuation of any switch at this time will silence the alarm and will cause the last set time to be displayed. (The latter will also occur when the ten second alarm time has expired). If the instrument is in elapsed time mode, the operator has the option of actuating S2 to reset the time, or to restart the countdown by actuation of switch S7. If this is not done before the 10 sec alarm period has expired, however, the display will revert to the "Chrono/Timer" display.

If, instead, the instrument is in a mode other than elapsed time mode, the operator has four seconds in which to either: 1) Restart the elapsed time by actuation of switch S7; 2) reset the timer to read "Chrono/Timer" (FIG. 4) by actuation of switch S2; or 3) enter set mode by actuation of switch S4, enter a new countdown time, and then exit set mode and restart the new set time by manual actuation of switches S2 and S7, respectively. (In the latter case the four second limitation does not apply during set mode and therefore the four second period does not begin until exiting set mode.) If either no switches are actuated or the four second period has elapsed, the original set time will be displayed.

Reference to FIG. 4 also shows that at any time when the instrument is displaying elapsed time mode, the operator may instead display distance to be traveled, by manually actuating S1 which will also actuate the lamp. A second actuation of S1 will return the instrument to elapsed time display. Subsequent repeated actuation of S1 will cause the instrument to alternately display elapsed time and distance to be traveled modes.

Reference to FIG. 5 shows that the pace mode subroutine provides for three different pace mode displays: steps per minute ("ST"); minutes per mile ("MM"); and miles per hour ("MH"). Repeated manual actuation of S7 will cycle the pace mode through these three displays.

FIG. 5 also shows the basic operation of stride calibration mode. The stride calibration mode allows the operator to enter his own stride length which is, used in calculations performed by the program, particularly rate of travel in minutes per mile and miles per hour (FIG. 5), and distance to be traveled (FIG. 4). The integrated circuit program is designed to store in memory, certain constant conversion factors, including operator stride length in feet ("FT") and inches ("IN") or centimeters ("CM"), the number of feet and inches and centimeters in one mile and the number of minutes in one hour, which are necessary to the aforementioned calculations.

An example of a calculation using the operator's stride length is as follows: In order to calculate miles per hour, the program is designed to perform calculations which multiply stride length, currently stored pace (in steps per minute), and two conversion factors (mile/5280 feet and 60 minutes/1 hour). Thus if the operator's stride were 3 feet, 6 inches, and his pace were 135 steps per minute, the program would calculate the operator's rate of travel in miles per hour to be 5.4 (FIG. 5). (That is, 3.5 feet/step$\times$135 step/minute$\times$1 mile/5280 feet$\times$60 minutes/1 hour is equal to 5.4 when rounded off to the nearest tenths). Minutes per mile can be calculated by taking the inverse of the product of miles per hour and the conversion factor of 1 hour/60 minutes.

Distance to be traveled can be similarly calculated by multiplying the present elapsed time (FIG. 4) by the currently stored pace in steps per minute (FIG. 5), operator's stride length, and a conversion factor of 1 mile/5280 feet. Thus, for example, if elapsed time were 25 minutes (FIG. 4), currently stored pace were 135 steps per minute (FIG. 5), and length of operator stride were 3.5 feet per step, (FIG. 5), the program would calculate the distance to be traveled as 2.2372 miles (FIG. 4). (That is, 25 minutes$\times$135 steps/minute$\times$3.5 feet/-

step×1 mile/5280 feet is equal to 2.2372 miles when rounded to the nearest ten-thousandths).

The operator may enter calibration mode by manually actuating S4 while in any of the three pace displays. The display will show calibration in feet and inches but the operator may instead display centimeters by actuating S7. Again the program is designed to store as a constant, the conversion factor of centimeters per mile. In either case, either S1 or S6 will advance the display forward, while either S2 or S5 will decrement the display. The operator may exit the calibration mode by actuating S4 again in which case the display will be returned to the original pace display.

Reference to FIGS. 6 and 7 illustrate the general operation of the pace confirmation and adjustment program which can be entered from any mode by manual actuation of S6. FIG. 6 shows that the actuation of S6 the first time will cause the last pace mode to be displayed. Thus, for example, if the operator viewed the pace mode in miles per hour, and had subsequently left pace mode to view other modes, he would upon manual actuation of S6 be returned to the miles per hour pace mode display. The pace confirmation and adjustment routine is illustrated generally by the blocks 19 and 20 of FIG. 6.

FIG. 7 is a flow chart explaining in more detail the operation of the pace confirmation and adjustment program. More specifically, it explains how the operator may readily synchronize the pace which is set in the instrument with his own natural pace.

As stated previously, the first actuation of S6 will cause to be displayed whatever pace mode was last viewed by the operator. At the moment this pace is displayed, an interval timer and incremental counter are started and a preselected number of audible confirmation beeps begins. The number of confirmation beeps is any convenient number, but ten beeps are used in the preferred embodiment. The confirmation beeps occur periodically at a rate equivalent to that preselected operator pace that is currently being stored in pace mode.

Thus if 60 steps per minute is currently stored in pace mode, the beeps will occur one every second (i.e., 60 steps/minute=1 step/second) for a total of ten beeps. Similarly, a pace display of 90 steps per minute will correspond to a rate of three audible beeps every two seconds (90 steps/minute=3 steps/2 seconds) for a total of ten beeps, i.e., having a frequency proportional to the preselected operator pace.

Once the pace adjustment mode has been initiated by the depression of S6, the operator must depress S6 a second time to calculate a new pace. Actuation of S6 operates a switch closure inside the timepiece which remains closed only for as long as S6 is depressed. In the disclosed invention the altered or new pace mode is determined by the time elapsed between the opening of the switch closure after the first depression or actuation of S6 and the closing of this switch closure upon the second depression or actuation of S6.

It is understood that it is well within the scope of the invention, however, for the program to be designed so that the new or altered pace mode is determined during one depression of S6; wherein first and second actuation of S6 respectively comprise the depression and release of S6 by the operator. This depression and release in turn correspond respectively to the closing and opening of the switch closure during this one depression. The time elapsed between the closing and opening of the switch closure during this one depression determines the new or altered pace mode.

The time elapsed between first and second actuation is determined by the operator of the timepiece. The first actuation when the operator's foot hits the ground commences a timing event. The second actuation when the operator's foot hits the ground again terminates the timing event. The program alters the previous preselected pace to calculate a new or altered pace and stores it in memory in place of the previous preselected pace.

As FIG. 7 shows, in order to set a new pace, the second actuation of S6 must occur before the incremental counter has reached a count of 11 (FIG. 7) and the audible device has sounded a total of 10 confirmation beeps. If S6 is not actuated before the incremental counter has reached 11 or before 10 confirmation beeps, the display is returned to that mode which was displayed before the first actuation of S6.

Additionally, the second actuation of S6 must also occur before four seconds have elapsed since the starting of interval timer. The function of the interval timer is to reduce the time that the integrated circuit must wait for a second input, and thus serves to determine when the chip need no longer wait for a second actuation of S6. Therefore, as FIG. 7 shows, the program will check the status of the interval timer, and if S6 is actuated a second time before the ten confirmation beeps, but after 4 seconds have elapsed since the interval timer was first started, then the interval timer is restarted and incremental "beep counter" reset, but no new pace is calculated.

If the user actuates S6 a second time before the ten confirmation beeps and before 4 seconds have elapsed, a new pace is calculated as described above, and the display is updated to show the new pace. Additionally, a 0.5 second beep sounds to indicate that a new pace has been calculated. Once this new pace has been calculated, a new set of confirmation beeps is produced by the alarm.

Finally, at any time after the confirmation mode has been started, it can be cancelled by the actuation of any switch except S1 and S6.

The programming steps necessary to carry out the flow chart steps illustrated in FIG. 7, so as to alter and store a previously selected pace and to subsequently perform calculations using this altered pace as previously described are well within the scope of those skilled in the programming art, and are readily incorporated into the operating program of the integrated circuit.

The term "state" and "mode" are used interchangeably herein and are not intended by way of limitation.

While there has been described what is considered to be the preferred embodiment of the invention, other modifications will become known to those skilled in the art and it is desired to cover, in the appended claims, all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. Improvement in a multimode electronic timepiece having an electroptic display, an audible device, a plurality of manually actuated actuators and a mask programmable integrated circuit programmed to keep time and to provide a plurality of timepiece operating modes including a pace mode, wherein said integrated circuit is programmed to permit an operator to switch between modes in response to actuation of at least a first of said actuators; said integrated circuit being further pro-

grammed to accept and store information in memory in response to actuation of at least a second of said actuators, to perform calculations thereon and to display said information and results of said calculations on said elec display; said integrated circuit being further programmed to provide, upon actuation of at least a third of said actuators, audible periodic electronic sounds produced by said audible device, wherein the frequency of said sounds varies proportionately to the value of a preselected pace of said operator, and wherein said improvement comprises:

means responsive to first manual actuation of a selected actuator coinciding with one footfall of the operator to commence a timing event;

means responsive to second manual actuation of said selected actuator coinciding with a later footfall of the operator to terminate said timing event;

program means to alter said preselected pace and store an altered pace which is inversely proportional to the time elapsed between first and second actuation of said selected actuator; and,

means for displaying said altered pace and causing said audible device to sound at a rate equivalent to said altered pace.

2. The improvement according to claim **1**, wherein at least said selected actuator is a pushbutton which operates switch closures inside said timepiece, wherein said switch closures are closed only for so long as said pushbutton is depressed.

3. The improvement according to claim **2**, wherein said elapsed time comprises the time between the opening of said switch closure after first actuation of said selected actuator and the closing of said switch closure upon said second actuation of said selected actuator.

4. The improvement according to claim **2**, wherein said first and second actuation of said selected actuator respectively comprise the manual depression and release of said selected actuator by said operator, wherein said depression and release of said selected actuator respectively correspond to the closing and opening of said switch closure, and wherein said elapsed time comprises the time between said opening and closing of said switch closure.

5. The improvement according to claim **1**, wherein said program means include an interval timer and incremental counter.

6. The improvement according to claim **5**, wherein said program means are adapted to cause said audible device to produce a preselected number of sounds at a rate which varies proportionately to the pace value which is being currently stored in said pace mode.

7. The improvement according to claim **5**, wherein said program means are adapted to provide for the return from a currently displayed mode to the mode last displayed before actuation of said selected actuator, if said selected actuator is not actuated within a predetermined count on said incremental counter.

8. The improvement according to claim **5**, wherein said program means are adapted to provide for the checking of the status of said interval timer, and the resetting of said incremental counter and restarting of said interval timer if the difference in time between first and second actuation of said selected actuator exceeds a predetermined time to which said interval timer is set.

9. The improvement according to claim **1**, wherein said integrated circuit is programmed to perform calculations and to display in said pace mode, a plurality of states selected from the group consisting of: steps per minute; minutes per mile; and miles per hour.

10. The improvement according to claim **9**, wherein said integrated circuit is programmed to allow said operator, while in said pace mode, to cycle said timepiece through said plurality of states in a preselected manner through repeated manual actuation of one of said actuators.

11. The improvement according to claim **1**, wherein said integrated circuit is programmed to provide for a calibration mode having means for storing an operator stride length, to display said value in response to actuation of one of said actuators and, whereby said operator may alter the value of said length of operator stride through the actuation of one of said plurality of said actuators.

12. The improvement according to claim **11**, wherein said integrated circuit is programmed to allow said operator to alternately display said length of operator stride in feet and inches or centimeters through the actuation of one of said actuators.

13. The improvement according to claim **1**, wherein said integrated circuit is programmed to provide for an elapsed time mode, and to count down from a preselected time to continuously compute an elapsed time.

14. The improvement according to claim **13**, wherein said integrated circuit is programmed to store an operator stride length and to perform calculations to compute a distance to be traveled based on said elapsed time and said stride length.

15. The improvement according to claim **14**, wherein said integrated circuit is programmed to allow an operator to alternately display said elapsed time and said distance to be traveled through the repeated actuation of one of said actuators.

16. The improvement according to claim **13**, wherein said integrated circuit is programmed to automatically place said timepiece in said elapsed time mode at preselected times after said elapsed time mode has been initiated.

17. The improvement according to claim **16**, wherein said timepiece is placed in said elapsed time mode at a time that is one half of said preselected time to which said operator has set said elapsed time mode and wherein said electroptic display includes an indicia representing half of the distance to be traveled, and having means to actuate said indicia.

* * * * *

Evidence Appendix B (37 C.F.R. § 41.37(c)(1)(ix))
U.S. Patent No. 5,526,290 to Kanzaki

This patent was originally made of record and relied upon by the Office in the First Office Action mailed February 20, 2004.

US005526290A

United States Patent [19]

Kanzaki

[11] Patent Number: 5,526,290

[45] Date of Patent: Jun. 11, 1996

[54] **PACE CALCULATION DEVICES**

[75] Inventor: **Takashi Kanzaki**, Akishima, Japan

[73] Assignee: **Casio Computer Co., Ltd.**, Tokyo, Japan

[21] Appl. No.: **283,038**

[22] Filed: **Jul. 29, 1994**

[30] **Foreign Application Priority Data**

Aug. 4, 1993 [JP] Japan 5-213381

[51] **Int. Cl.**[6] **G01P 1/00**

[52] **U.S. Cl.** **364/565**; 364/569; 377/24.2; 482/3; 235/105

[58] **Field of Search** .... 364/565, 561, 364/569; 377/24.2, 5, 24; 340/321, 323 R, 309.15; 368/108, 89, 110, 243, 113, 244, 251; 482/3, 74; 968/398; 235/105

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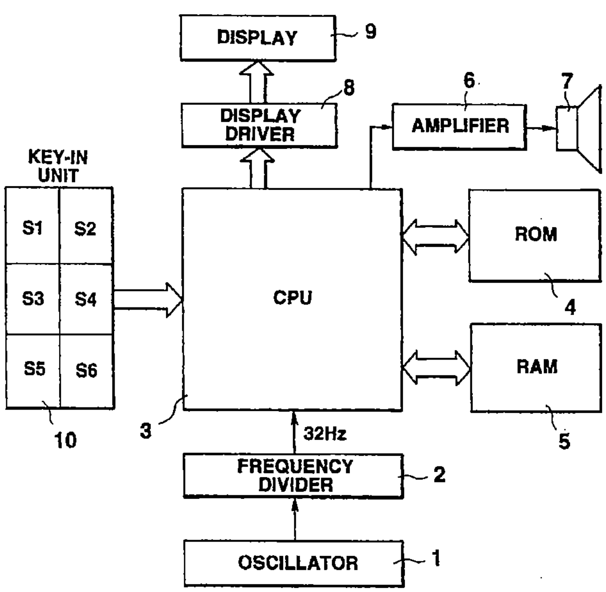
Primary Examiner—James P. Trammell

Attorney, Agent, or Firm—Frishauf, Holtz, Goodman, Langer & Chick

[57] **ABSTRACT**

A pace calculation device including an oscillator and a frequency divider used for timing purposes, an amplifier and a speaker for generating a signal sound, and a CPU for performing an operation. Times taken for a runner to run any first distance twice each at a different pace to the signal sound are measured. The CPU draws a relation between a pace and a run time on the basis of data on two different paces at each of which the runner run the first distance and data on the run times taken for the runner to run. A run time taken for the runner to run at any pace any second distance which the runner should run in a target run time is measured. The CPU calculates a pace at which the runner runs the second distance in the target run time on the basis of the relation, data on the pace at which the runner run the second distance, and the run time taken for that run. The speaker generates a signal sound on the basis of data on the pace calculated by the CPU.

18 Claims, 13 Drawing Sheets



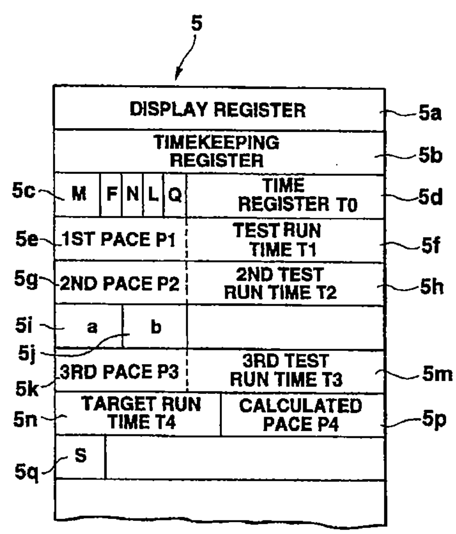


FIG.1

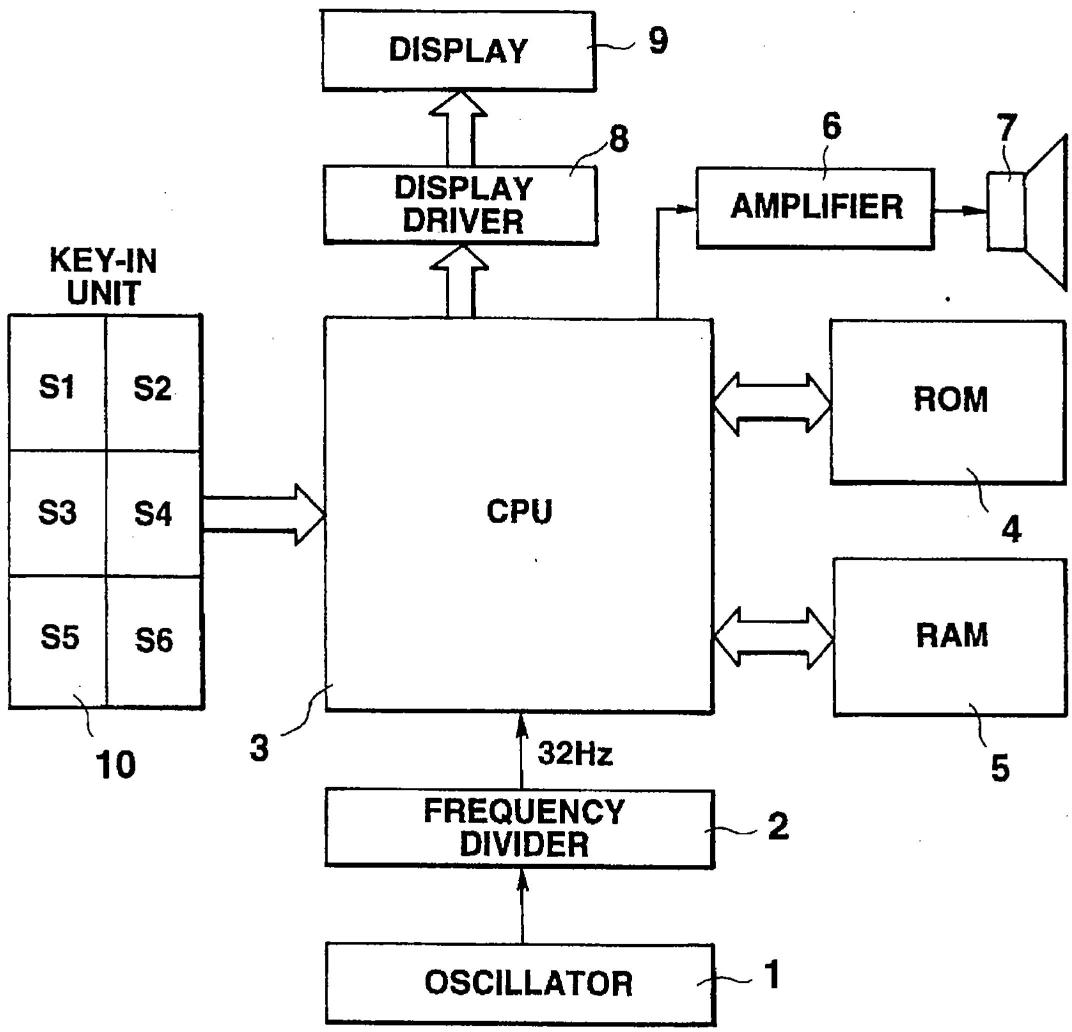

DISPLAY
9
DISPLAY DRIVER
8
6
7
AMPLIFIER
KEY-IN UNIT
S1
S2
S3
S4
S5
S6
10
CPU
3
ROM
4
RAM
5
32Hz
FREQUENCY DIVIDER
2
OSCILLATOR
1

FIG.2

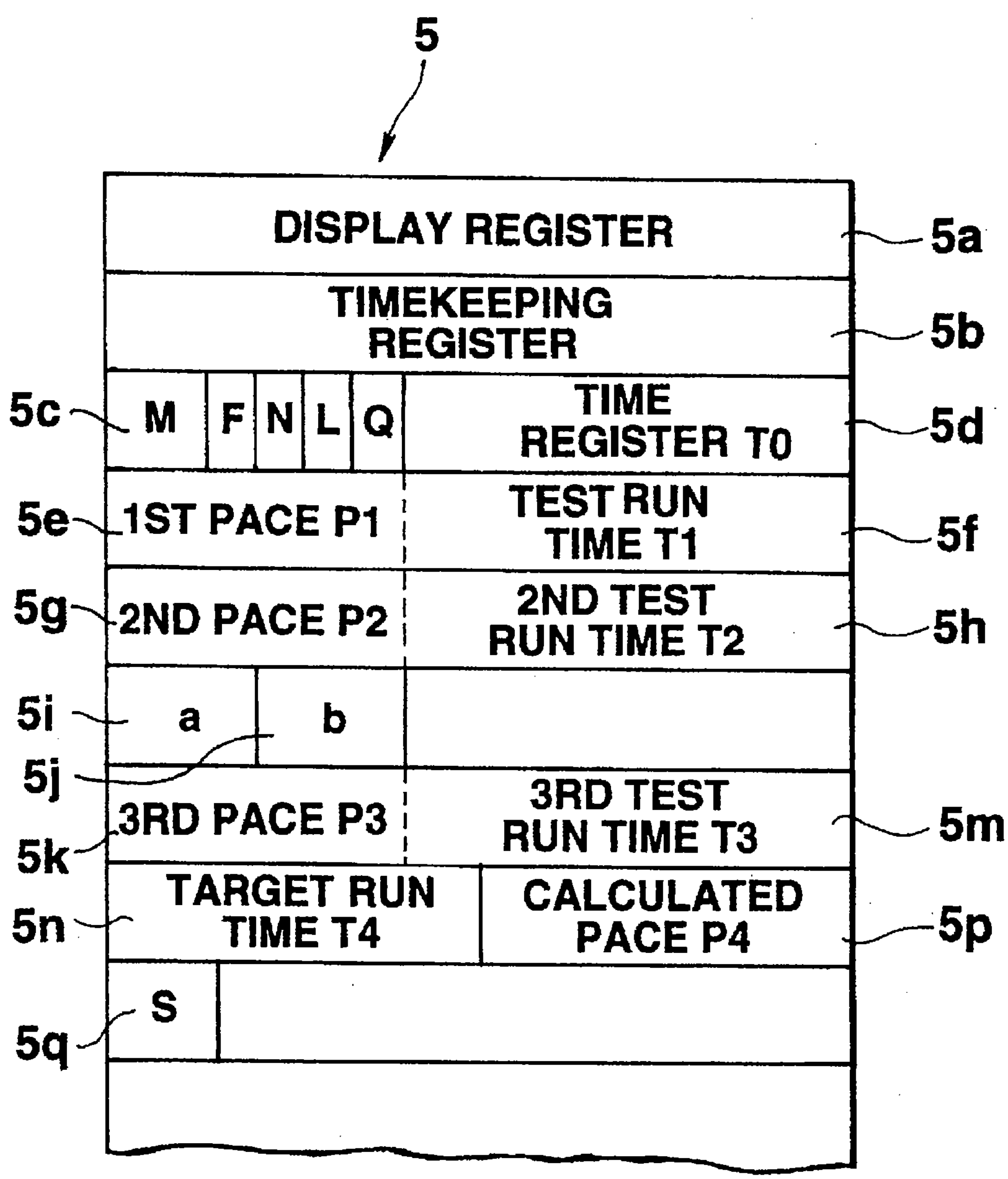

5
DISPLAY REGISTER
5a
TIMEKEEPING REGISTER
5b
5c
M
F
N
L
Q
TIME REGISTER T0
5d
5e
1ST PACE P1
TEST RUN TIME T1
5f
5g
2ND PACE P2
2ND TEST RUN TIME T2
5h
5i
a
b
5j
3RD PACE P3
3RD TEST RUN TIME T3
5k
5m
5n
TARGET RUN TIME T4
CALCULATED PACE P4
5p
S
5q

FIG.3

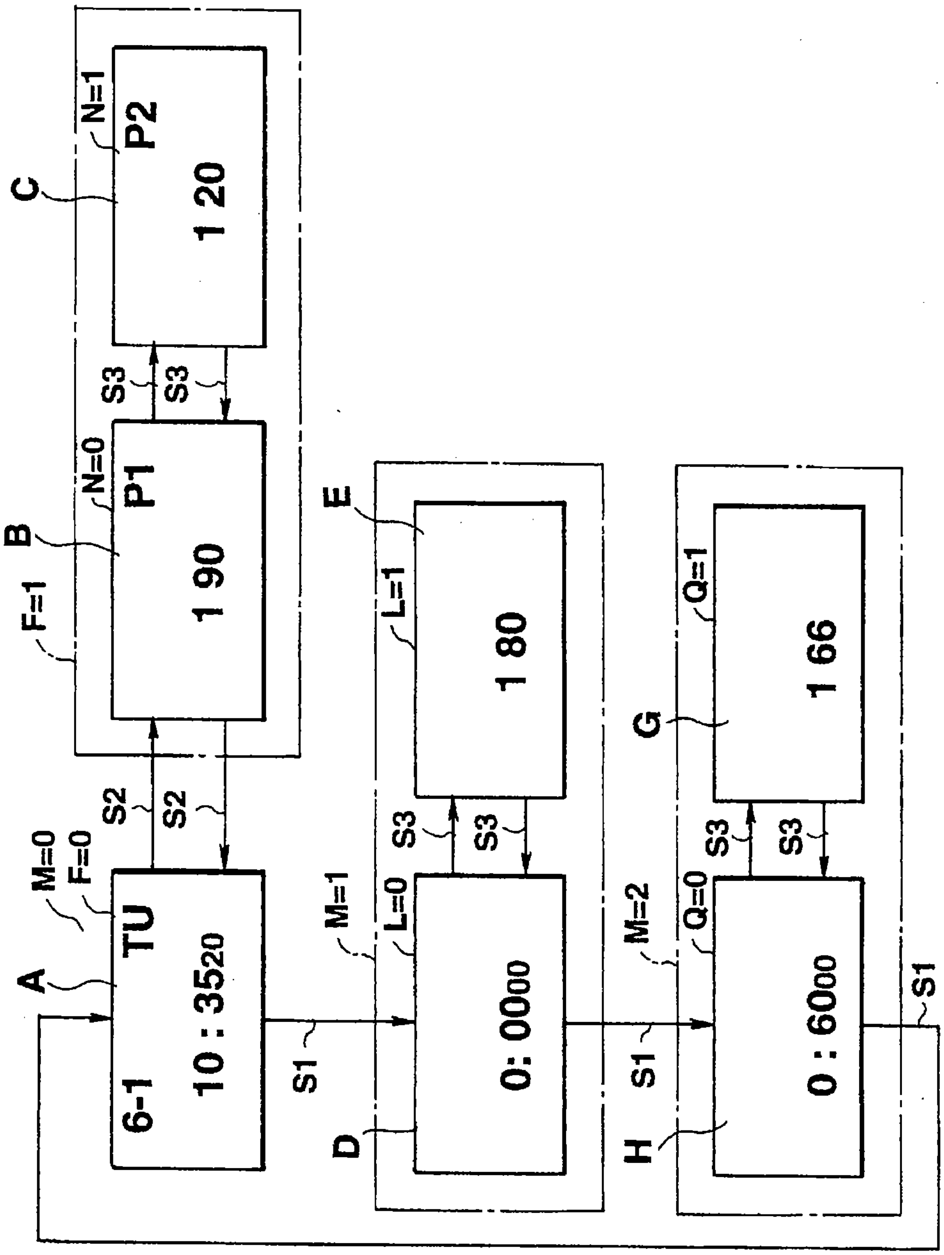

A
B
C
D
E
G
H
TU
6-1
10 : 3520
P1
1 90
P2
1 20
0: 0000
1 80
0 : 6000
1 66
M=0
F=0
F=1
N=0
N=1
M=1
L=0
L=1
M=2
Q=0
Q=1
S1
S2
S3

FIG.4

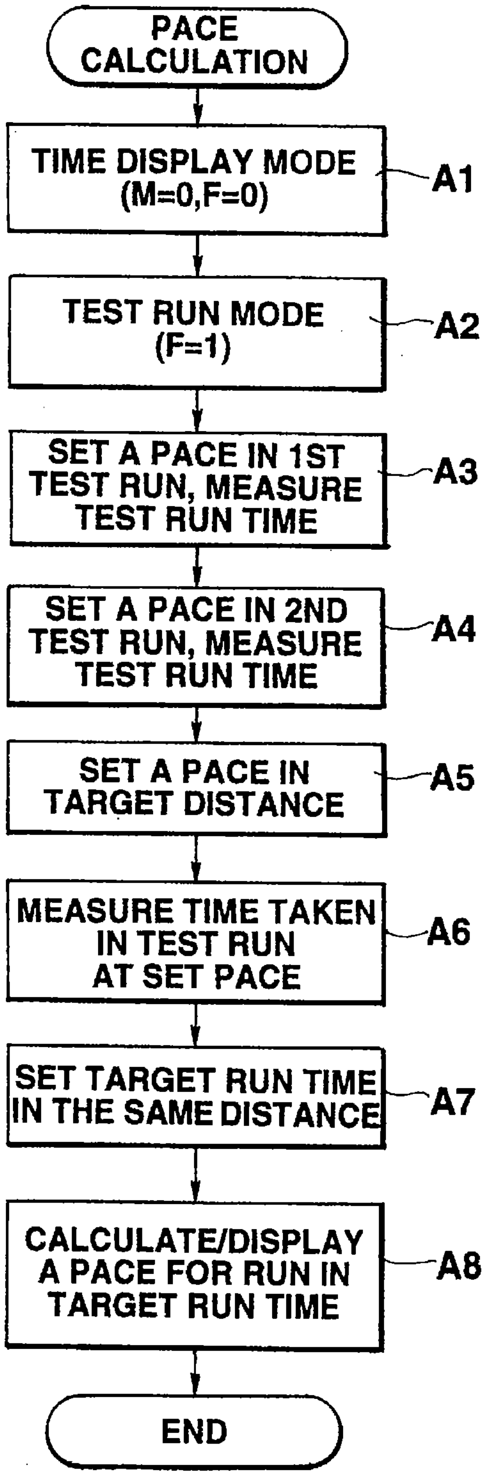

PACE CALCULATION
TIME DISPLAY MODE (M=0,F=0)
A1
TEST RUN MODE (F=1)
A2
SET A PACE IN 1ST TEST RUN, MEASURE TEST RUN TIME
A3
SET A PACE IN 2ND TEST RUN, MEASURE TEST RUN TIME
A4
SET A PACE IN TARGET DISTANCE
A5
MEASURE TIME TAKEN IN TEST RUN AT SET PACE
A6
SET TARGET RUN TIME IN THE SAME DISTANCE
A7
CALCULATE/DISPLAY A PACE FOR RUN IN TARGET RUN TIME
A8
END

FIG.5

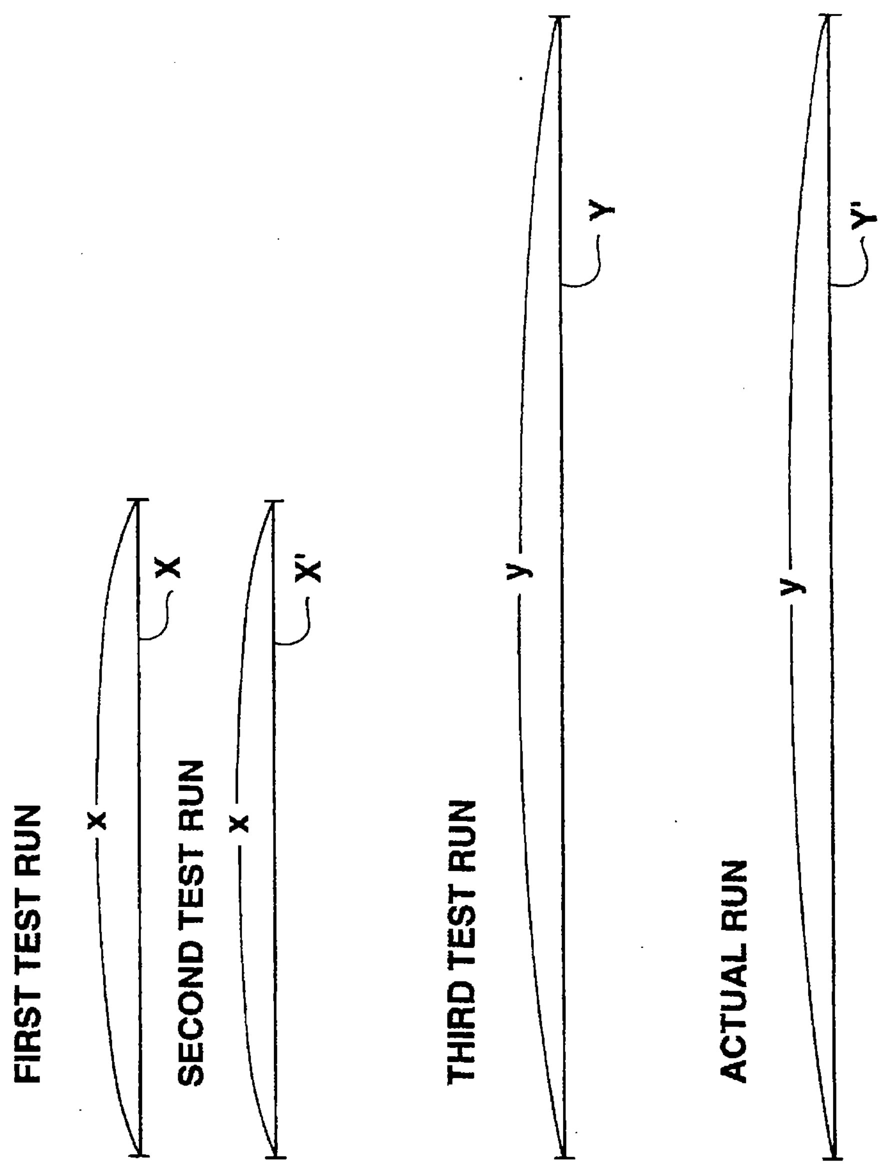

FIRST TEST RUN
x
X
SECOND TEST RUN
x
X'
THIRD TEST RUN
y
Y
ACTUAL RUN
y
Y'

FIG.6

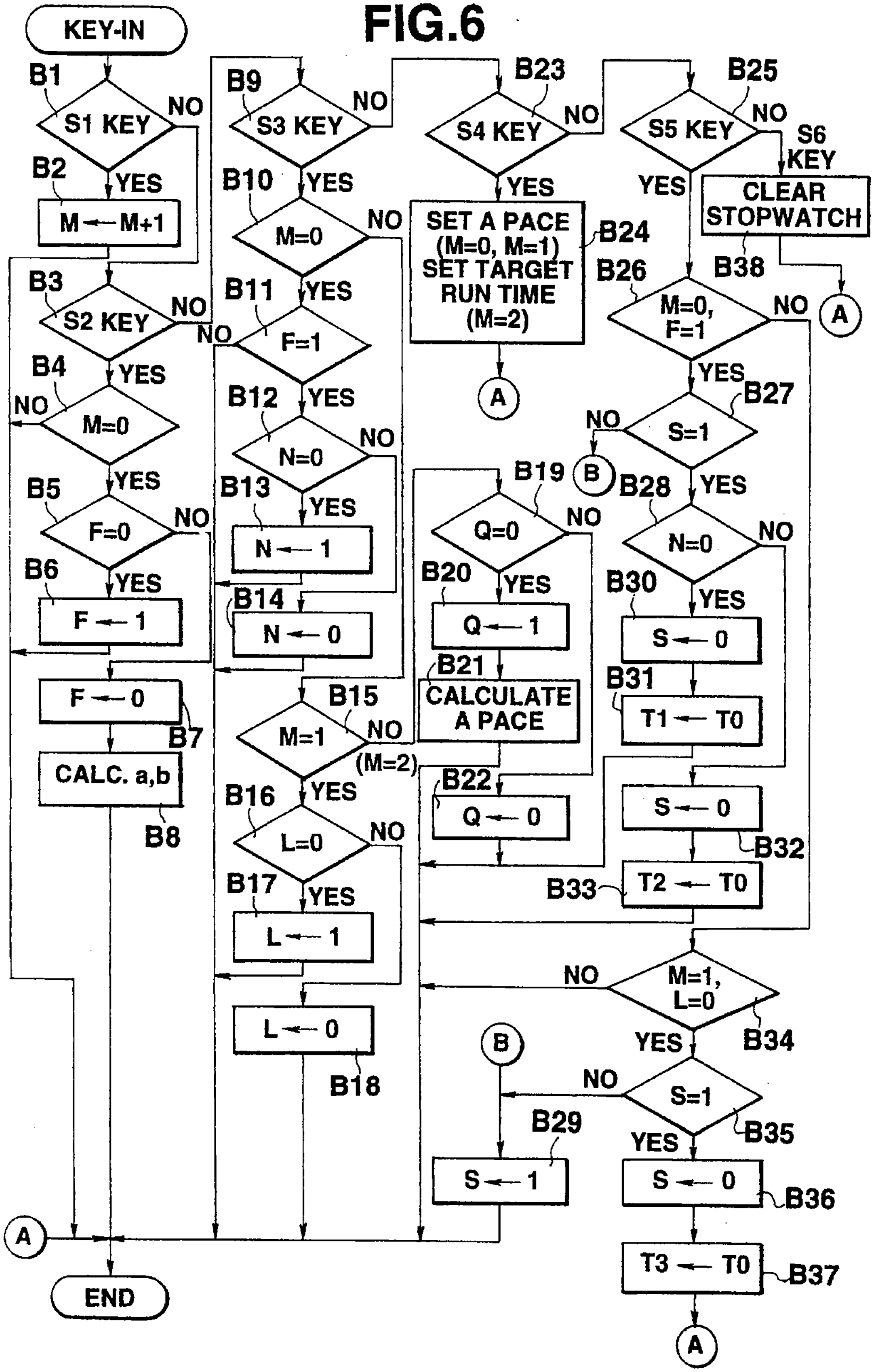
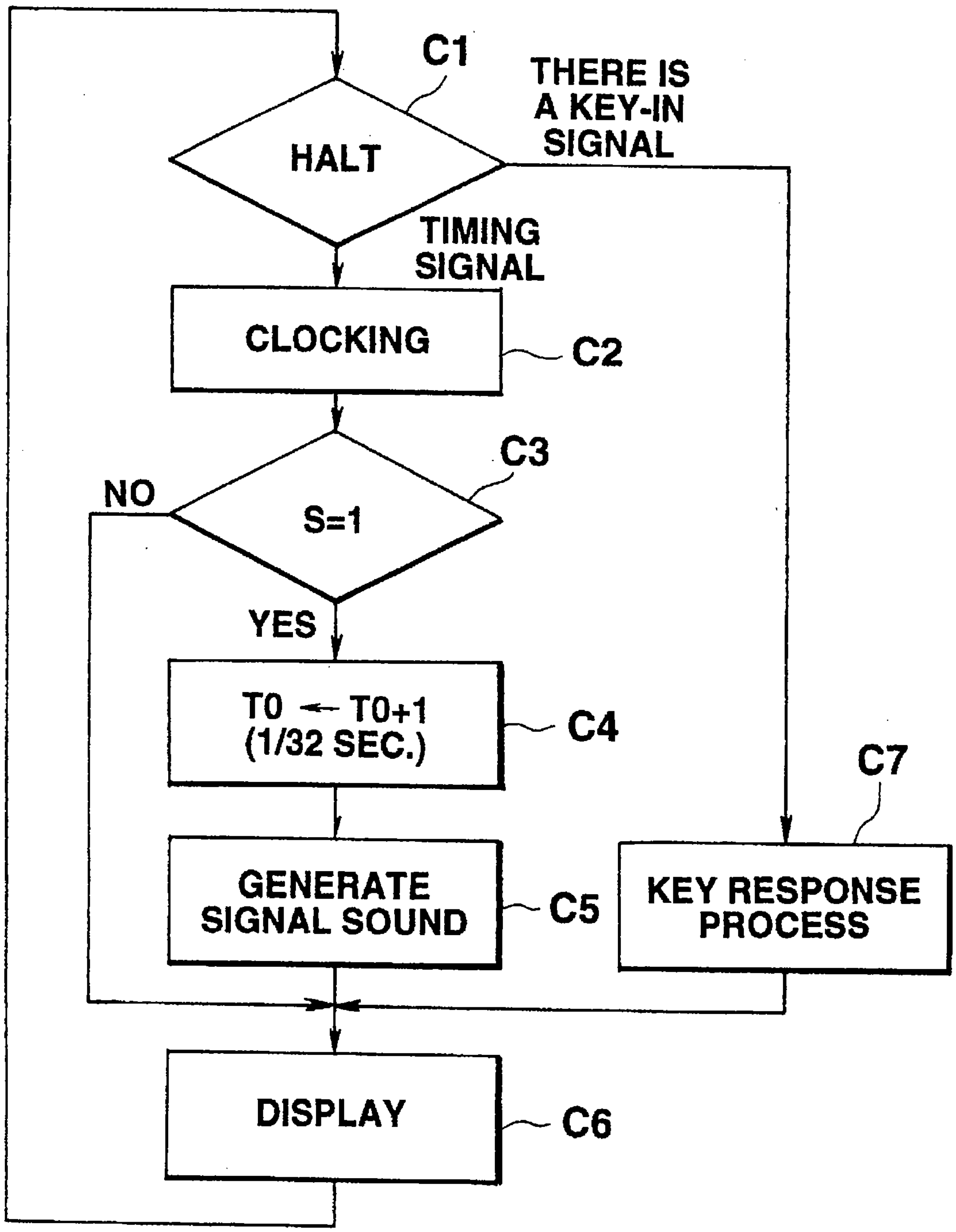

KEY-IN
B1
S1 KEY
NO
YES
B2
M ← M+1
B3
S2 KEY
NO
YES
B4
M=0
NO
YES
B5
F=0
NO
YES
B6
F ← 1
F ← 0
B7
CALC. a,b
B8
B9
S3 KEY
NO
B10
M=0
NO
B11
F=1
NO
B12
N=0
B13
N ← 1
B14
N ← 0
B15
M=1
(M=2)
B16
L=0
B17
L ← 1
L ← 0
B18
B23
S4 KEY
SET A PACE
(M=0, M=1)
SET TARGET
RUN TIME
(M=2)
B24
A
B19
Q=0
B20
Q ← 1
B21
CALCULATE
A PACE
B22
Q ← 0
B25
S5 KEY
S6
KEY
CLEAR
STOPWATCH
B38
B26
M=0,
F=1
B27
S=1
B
B28
N=0
B30
S ← 0
B31
T1 ← T0
S ← 0
B32
B33
T2 ← T0
M=1,
L=0
B34
S=1
B35
B29
S ← 1
S ← 0
B36
T3 ← T0
B37
END

FIG.7



C1
HALT
THERE IS
A KEY-IN
SIGNAL
TIMING
SIGNAL
CLOCKING
C2
C3
NO
S=1
YES
T0 ← T0+1
(1/32 SEC.)
C4
C7
GENERATE
SIGNAL SOUND
C5
KEY RESPONSE
PROCESS
DISPLAY
C6

FIG.8

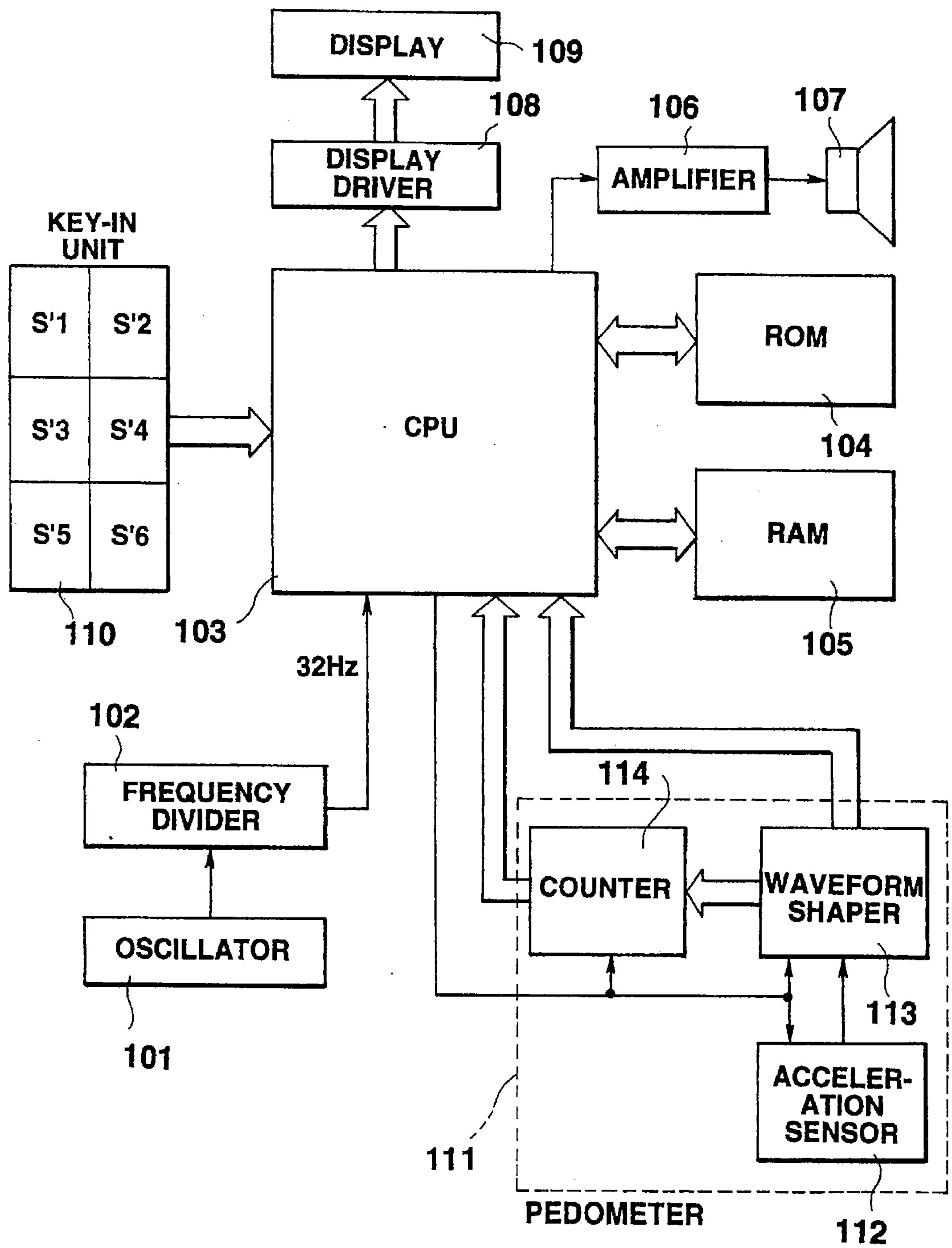

DISPLAY
109
108
DISPLAY DRIVER
106
AMPLIFIER
107
KEY-IN UNIT
S'1
S'2
S'3
S'4
S'5
S'6
CPU
ROM
104
RAM
105
110
103
32Hz
102
FREQUENCY DIVIDER
OSCILLATOR
101
114
COUNTER
WAVEFORM SHAPER
113
ACCELER-ATION SENSOR
111
PEDOMETER
112

FIG.9

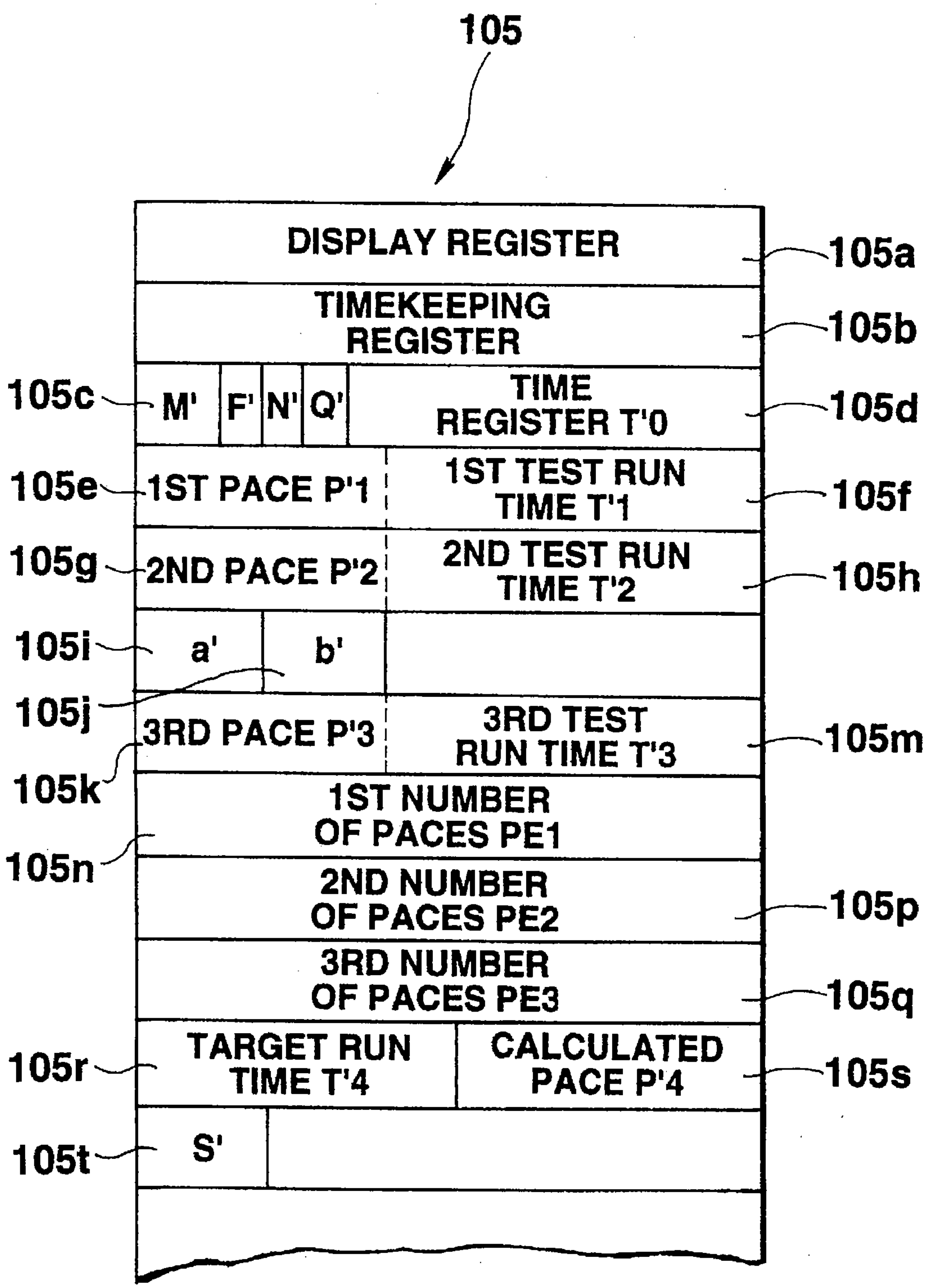

105
DISPLAY REGISTER
105a
TIMEKEEPING REGISTER
105b
105c
M'
F'
N'
Q'
TIME REGISTER T'0
105d
105e
1ST PACE P'1
1ST TEST RUN TIME T'1
105f
105g
2ND PACE P'2
2ND TEST RUN TIME T'2
105h
105i
a'
b'
105j
3RD PACE P'3
3RD TEST RUN TIME T'3
105m
105k
1ST NUMBER OF PACES PE1
105n
2ND NUMBER OF PACES PE2
105p
3RD NUMBER OF PACES PE3
105q
105r
TARGET RUN TIME T'4
CALCULATED PACE P'4
105s
105t
S'

FIG.10

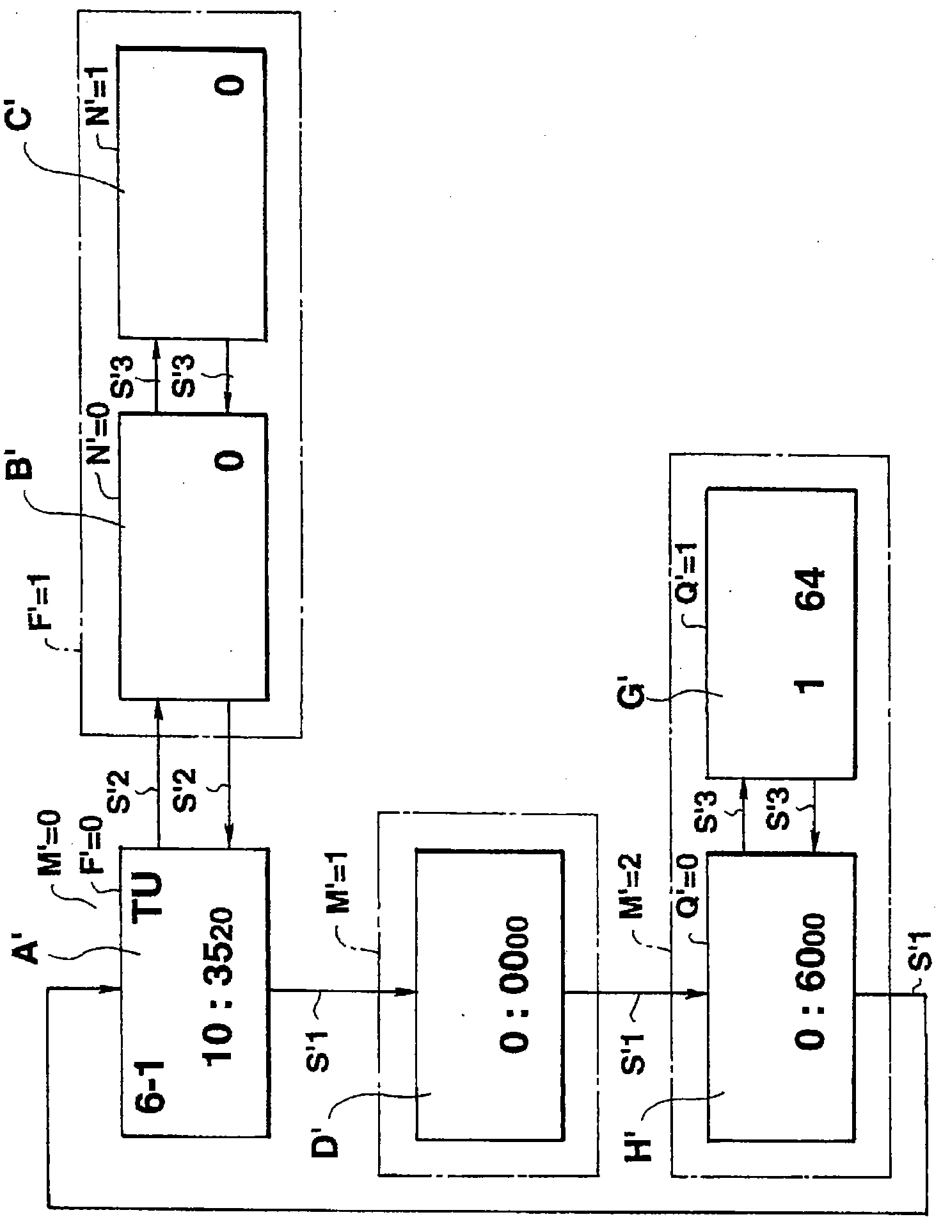

A'
M'=0
F'=0
TU
6-1
10 : 35 20
S'2
S'2
B'
N'=0
F'=1
0
S'3
S'3
C'
N'=1
0
S'1
M'=1
D'
0 : 00 00
S'1
M'=2
Q'=0
H'
0 : 60 00
S'3
S'3
G'
Q'=1
1
64
S'1

FIG.11

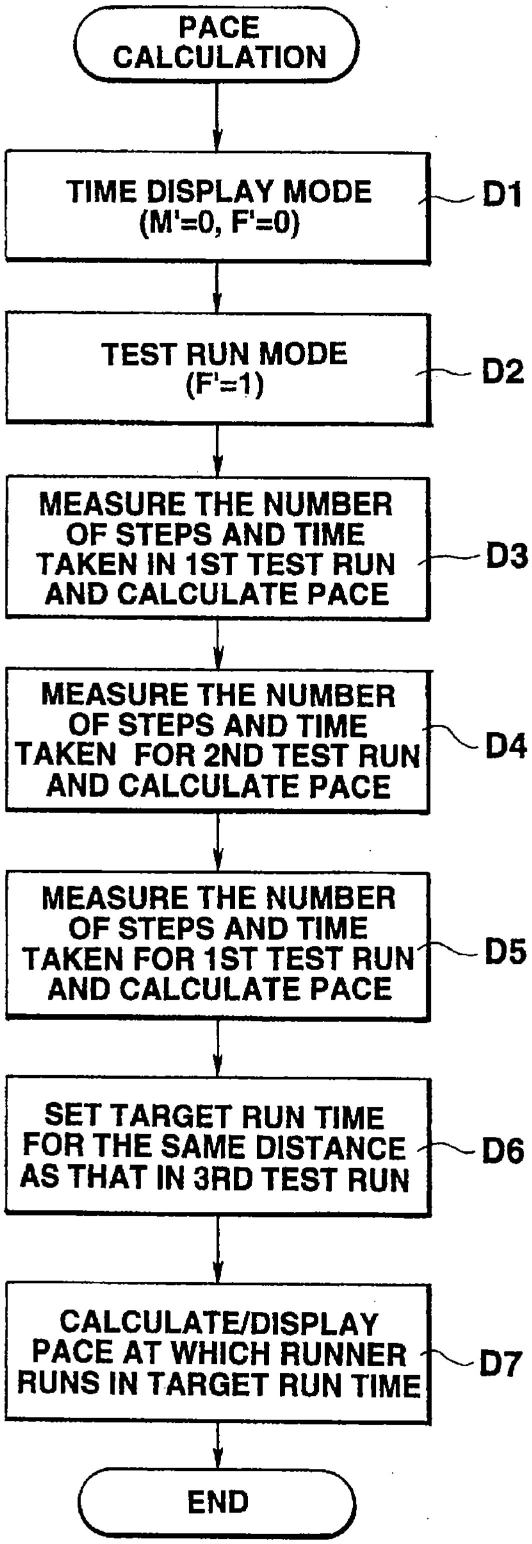

PACE CALCULATION
TIME DISPLAY MODE (M'=0, F'=0)
D1
TEST RUN MODE (F'=1)
D2
MEASURE THE NUMBER OF STEPS AND TIME TAKEN IN 1ST TEST RUN AND CALCULATE PACE
D3
MEASURE THE NUMBER OF STEPS AND TIME TAKEN FOR 2ND TEST RUN AND CALCULATE PACE
D4
MEASURE THE NUMBER OF STEPS AND TIME TAKEN FOR 1ST TEST RUN AND CALCULATE PACE
D5
SET TARGET RUN TIME FOR THE SAME DISTANCE AS THAT IN 3RD TEST RUN
D6
CALCULATE/DISPLAY PACE AT WHICH RUNNER RUNS IN TARGET RUN TIME
D7
END

FIG.12

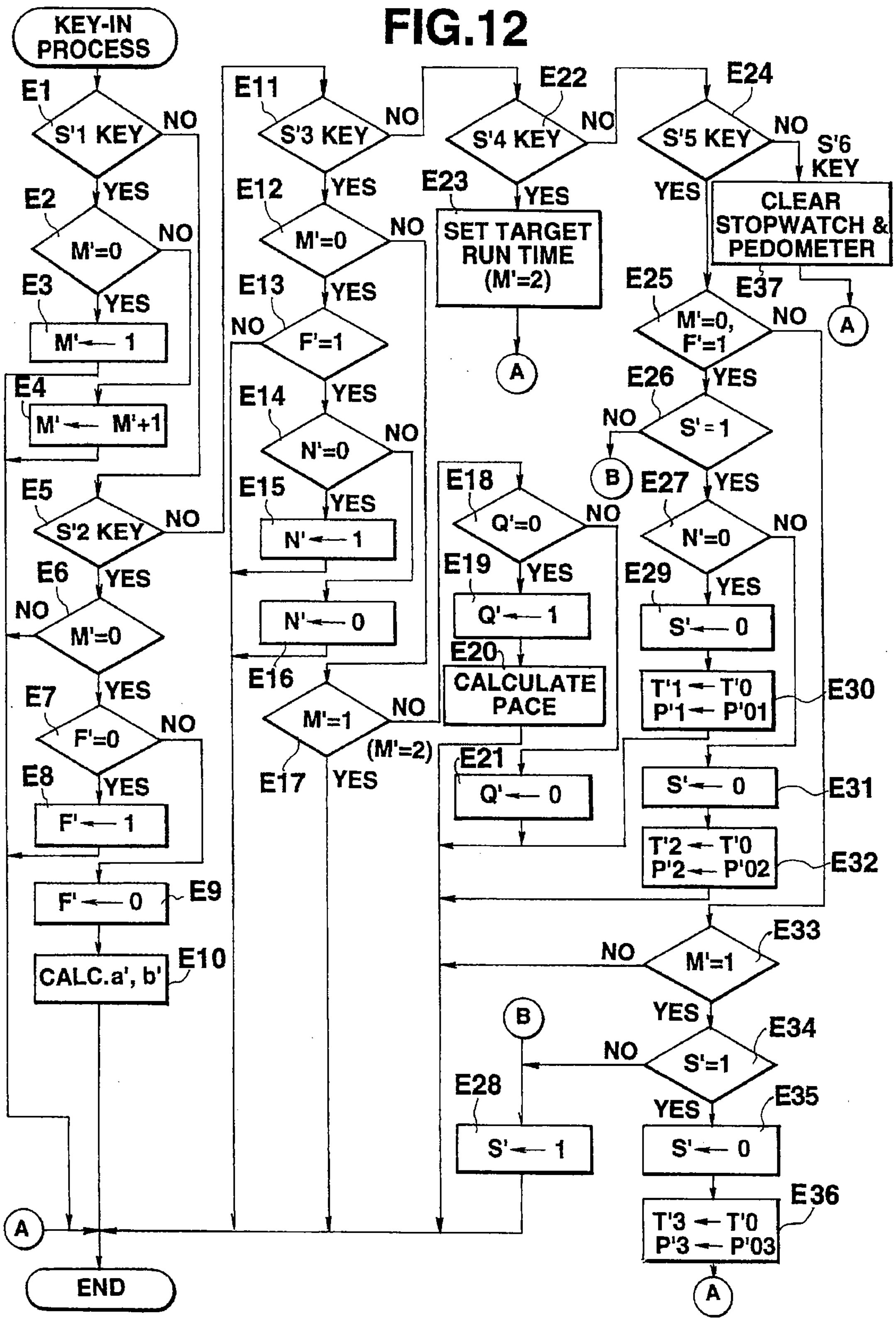
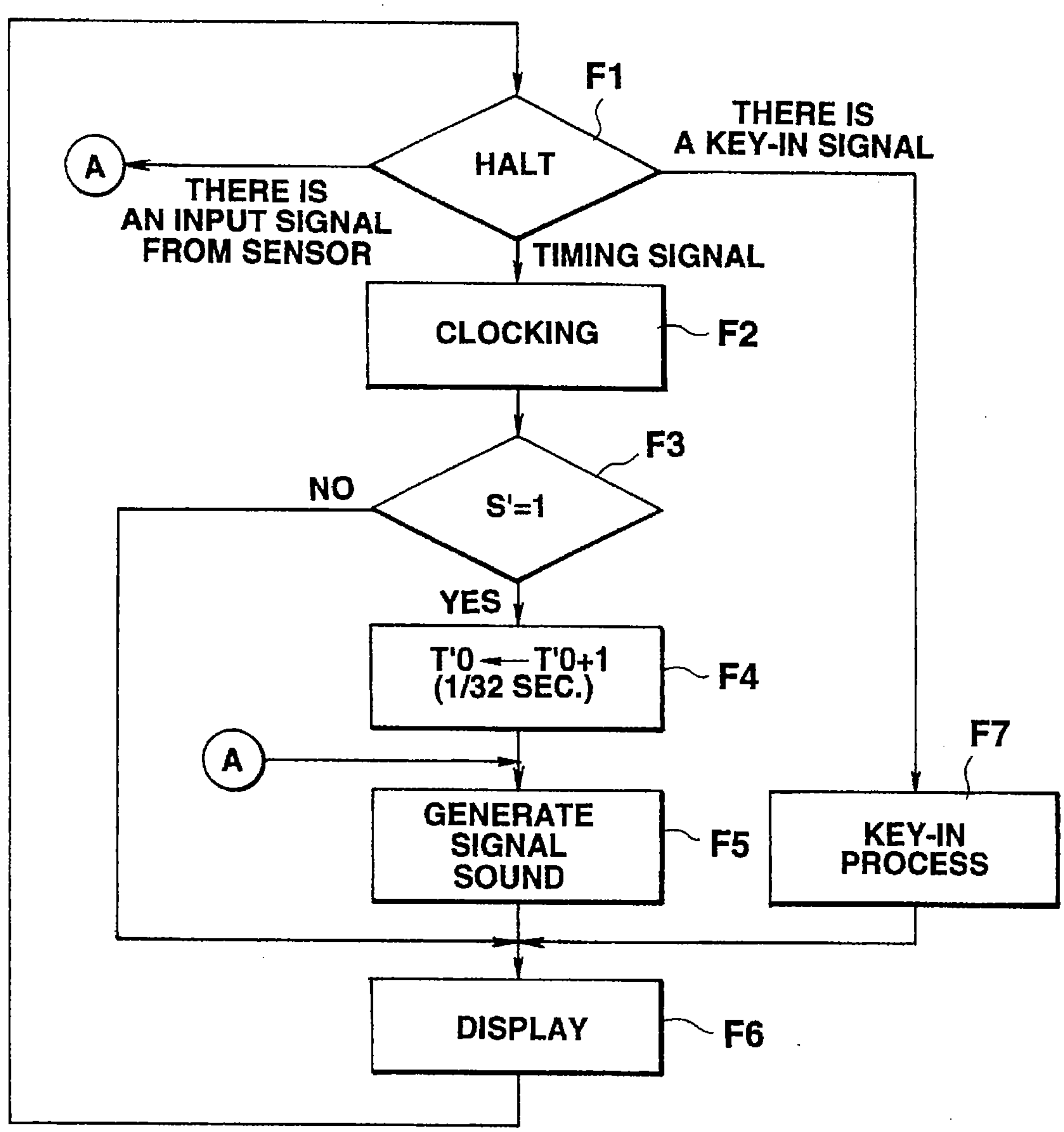

KEY-IN PROCESS
E1
S'1 KEY
NO
YES
E2
M'=0
E3
M'← 1
E4
M'← M'+1
E5
S'2 KEY
E6
M'=0
E7
F'=0
E8
F'← 1
F'← 0
E9
CALC.a', b'
E10
E11
S'3 KEY
E12
M'=0
E13
F'=1
E14
N'=0
E15
N'← 1
N'← 0
E16
M'=1
(M'=2)
E17
E22
S'4 KEY
E23
SET TARGET RUN TIME (M'=2)
E18
Q'=0
E19
Q'← 1
E20
CALCULATE PACE
E21
Q'← 0
E24
S'5 KEY
S'6 KEY
CLEAR STOPWATCH & PEDOMETER
E37
E25
M'=0, F'=1
E26
S'=1
E27
N'=0
E29
S'← 0
T'1 ← T'0
P'1 ← P'01
E30
S'← 0
E31
T'2 ← T'0
P'2 ← P'02
E32
M'=1
E33
S'=1
E34
S'← 0
E35
T'3 ← T'0
P'3 ← P'03
E36
E28
S'← 1
A
B
END

FIG.13


F1
HALT
THERE IS
A KEY-IN SIGNAL
A
THERE IS
AN INPUT SIGNAL
FROM SENSOR
TIMING SIGNAL
CLOCKING
F2
F3
NO
S'=1
YES
T'0 ← T'0+1
(1/32 SEC.)
F4
A
F7
GENERATE
SIGNAL
SOUND
F5
KEY-IN
PROCESS
DISPLAY
F6

PACE CALCULATION DEVICES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to pace calculation devices which determine a pace at which a person moves, for example, by walking or running.

2. Description of the Related Art

Generally, it is an important element that a runner runs while keeping his pace in a marathon or a long distance (for example, 10 km) running race in athletic sports. A runner participating in such a long distance running race can use a pace maker in his exercise.

The pace maker generates a signal such as a sound at given periods to the runner. The runner is able to run to the signal to keep his own pace.

Conventionally, a wrist watch having the function of generating a signal sound at a given period is known as a pace maker, which can change the period of the generated signal sound so as to match with a pace which the runner desires. When the runner runs, he wears this pace maker on his wrist.

However, the conventional pace maker has only the function of changing the period of generating a signal sound. Therefore, for example, it cannot be used in a manner in which, for example, a target run time taken for a runner to run any distance beforehand is determined and a pace appropriate for run of that distance in accordance with the target run time is set.

In this case, in order to obtain a pace p (for example, the number of steps per minute) at which the runner runs a course of a distance d in a target run time t, data items on the step w of the runner, distance d and target run time t are input to the device and the pace p is then required to be calculated in accordance with the following relation:

$$p=d\div w\div t.$$

Since the conventional pace makers have no such function, they cannot be used in a manner in which a pace appropriate for run of any distance in accordance with the target run time is set, as mentioned above.

Even if a pace maker is provided which is capable of obtaining a pace p by calculation such as is mentioned above, the number of data items to be set is large and the operation for keying in those data items is troublesome.

Some data items to set are unclear unless they are measured beforehand; for example, a distance a runner's step. Those data items are troublesome to prepare. If the prepared data items are inaccurate, a pace to be obtained would involve an error, disadvantageously. When the runner runs a course of an unclear distance, necessary data cannot be obtained so that the pace cannot be calculated and such function cannot be used at all.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a pace calculation device for calculating a pace (the number of steps per given time) at which a person moves through any distance by running or walking in accordance with a target movement time.

It is another object of the present invention to provide a pace calculation device for calculating a pace at which a person moves in accordance with a target movement time even in a course of an unclear distance without setting distance data.

It is still another object of the present invention to provide a pace calculation device convenient to use anywhere without requiring to set data difficult to recognize accurately such as data on the distance of a course which a person moves and his step at which he moves, and capable of obtaining a pace at which the person moves through any distance in accordance with an accurate target movement time.

It is a further object of the present invention to provide a pace calculation device capable of calculating a pace at which the person moves through any distance in accordance with a target movement time by a simple input operation.

In order to achieve the above objects, the present invention provides a pace calculation device comprising:

first storage means for storing data on a plurality of different paces at each of which a person moves through any first distance and data on a like number of different times each taken for the person to move through the first distance at a respective one of the paces;

second storage means for storing data on any pace at which the person moved through any second distance and data on a time taken for the person to move through the second distance;

third storage means for storing data on a target movement time taken for the person to move through the second distance at any pace; and

calculating means for calculating a pace at which the person moves through the second distance in the target movement time, based on data on which is stored in the third storage means, on the basis of the data on a plurality of paces and the data on a like number of movement times stored in first storage means, and the data on the pace and data on the movement time stored in the second storage means.

According to the inventive device having the above structure, data on a plurality of paces at each of which the person moves through the first distance (for example, of a test course through which the person moves for setting necessary data) and data on the corresponding plurality of movement times each taken for the movement are stored. The calculating means calculates a pace at which the person moves through the second distance (for example, of a real course which the person desires to run for exercising purposes) in the target movement time even when the step of the runner and the distance of the course are not set. Since no data on the accurate distance of a course which is difficult to recognize numerically in many cases is required, the device is easy to use and to calculate an accurate pace. This device is usable even when the distance of the course is unknown, and is not limited in use to a course of a known distance.

In order to achieve the above objects, the present invention provides a pace calculation device comprising:

first input means for inputting to the device data on a plurality of different paces at each of which a person moves through any first distance and data on a pace at which the person moves through any second distance;

second inputting means for inputting to the device data on a target movement time in which the person moves through the second distance at any pace;

timekeeping means for measuring movement times taken for the person to move through the first and second distances on the basis of the data on the respective paces inputted by the first inputting means to provide data on the movement times;

storage means for storing the data on a plurality of paces inputted by the first inputting means, the data on a target

movement time inputted by the second inputting means, the data on the movement times provided by the timekeeping means;

calculating means for drawing a relation between a pace and a movement time on the basis of the data on the movement times and the data on the paces for the movement of the person through the first distance, and calculating from the relation a pace at which the person moves through the second distance in the target movement time, based on data on which is inputted by the second input means; and

sounding means for generating a signal sound corresponding to the pace calculated by calculating means.

In the inventive calculation device having such structure, the input means input data on paces in the first distance (for example, of a test course) and data on a pace in the second distance (for example, in a real course) and data on a target movement time for the second distance. The timekeeping means measures the times taken for the person to move through the first and second distances. The storage means stores those data on the measured times. The calculating means obtains the relation between the pace and movement time, and data on the pace in the target movement time on the basis of the relation and the data on a target movement time inputted by the input means and stored in the storage means.

Thus, even when the distance of a course which the person moves in the target movement time is unknown, data on a pace at which the person moves in the target time is easily obtained, and the inventive device is usable in any place where the user desires. The inventive device eliminates the need for setting data, troublesome to deal with, such as data on the distance of a course and the person's step, so that it can easily be used by anybody to provide data on an accurate pace for the person.

In order to achieve the above objects, the present invention provides a pace calculation device comprising:

pedometer means for detecting the number of steps taken for a person to move through any first distance at each of a plurality of different paces and the number of steps taken for the person to move through any second distance at any pace;

timekeeping means for measuring the times taken for the person to move through the respective first and second distances when the respective numbers of steps are detected by said pedometer means;

input means for inputting to the device data on a target movement time taken for the person to move through the second distance;

first calculating means for calculating a plurality of paces at each of which the person moved through the first distance and a pace at which the person moved through the second distance on the basis of data on the numbers of steps obtained from said pedometer means and data on the movement times obtained from the timekeeping means;

storage means for storing data on the plurality of paces obtained from the first calculating means, data on the target movement time inputted by the input means, and data on the plurality of movement times obtained from the timekeeping means;

second calculating means for drawing a relation between a pace and a movement time on the basis of data on the plurality of paces and data on the plurality of movement times taken for the person to move through the first distance stored in said storage means, and calculating from the relation a pace at which the person moves through the second distance in the target movement time, based on data on which is input by said second input means; and

sounding means for generating a signal sound in correspondence to the pace calculated by the second calculating means.

In the inventive calculation device having such structure, the number-of-steps detecting means detects the numbers of steps taken for the person to move through any first distance (for example, of a test course) and any second distance (for example, of a real course). The timekeeping means measures the times taken for the person to move through those distances. The first calculating means calculates data on paces on the basis of those data items on the numbers of steps and the times taken for the person to move through the first and second distances. The storage means stores data on the paces calculated by the first calculating means and data on the target movement times inputted by the input means. The second calculating means obtains a relation between a pace and a movement time, and obtains data on a pace for the person to move through the second distance in the target movement time on the basis of data on the target movement time stored in the storage means.

Thus, even when the distance of a course through which the person moves in the target movement time is unknown, data on a pace at which the person moves in the target movement time is obtained easily. The inventive device is usable in any place where the person desires to use it and eliminates the need for setting data troublesome to deal with, such as data on the distance of a course and the runner's step, so that the inventive device is easily usable to provide data on an accurate pace.

Since the first calculating means calculates a pace on the basis of the numbers of steps detected by the number-of-steps detecting means and the times taken for the movement is measured by the timekeeping means, no data on the pace is required to be input and set. Thus, the inventive device is simple to operate and very convenient to use.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram indicative of the basic structure of a first embodiment of a pace calculation device according to the present invention;

FIG. **2** shows the structure of a memory area of the pace calculation device of the first embodiment;

FIG. **3** illustrates a process for changing a mode in the pace calculation device;

FIG. **4** is a flowchart indicative of a pace calculation method performed by the pace calculation device;

FIG. **5** illustrates a pace calculation method performed by the pace calculation device;

FIG. **6** illustrates a key response process performed in response to the depression of a key in the pace calculation device;

FIG. **7** is a flowchart indicative of an interrupt process performed in response to an interrupt occurring in the pace calculation device;

FIG. **8** is a block diagram indicative of the basic structure of a second embodiment of the pace calculation device according to the present invention;

FIG. **9** shows the structure of a memory area in the pace calculation device of the second embodiment;

FIG. **10** illustrates a process for changing a mode in the pace calculation device of the second embodiment;

FIG. **11** is a flowchart indicative of a pace calculation method performed by the pace calculation device of the second embodiment;

FIG. 12 illustrates a key response process performed in response to the depression of a key in the pace calculation device of the second embodiment; and

FIG. 13 is a flowchart indicative of an interrupt process performed in response to an interrupt occurring in the pace calculation device of the second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

A first embodiment of a pace calculation device according to the present invention will be described below. The pace calculation device of this embodiment is incorporated into an electronic wrist watch and has the function of calculating a pace as well as displaying the time as a wrist watch.

FIG. 1 is a block diagram indicative of the basic structure of the pace calculation device of the first embodiment. As shown in FIG. 1, the pace calculation device includes an oscillator **1** and a frequency divider **2** which cooperate to output a pulse signal of a predetermined period; a central processing unit (CPU) **3** which records the current time, measures elapsed time and calculates a pace (to be described later) on the basis of a pulse signal from the divider **2**; a read only memory (ROM) **4** which stores a program for controlling the operation of the CPU **3**; a random access memory (RAM) **5** which stores data; an amplifier **6** and a speaker **7** which cooperate to amplify a pace signal from the CPU **3** and output as a signal sound; a display driver **8** and a display **9** which cooperate to display the time, pace and elapsed time; and a key-in unit **10** which keys in data and changes a mode, as will be described later.

The oscillator **1** uses a well-known crystal resonator which generates a signal of a frequency, for example, of 32,768 Hz, depending on an oscillatory frequency inherent in the resonator.

The frequency divider **2** divides a signal from the oscillator **1** to obtain a signal of a reduced frequency and, in this embodiment, a signal of 32 Hz, which is then fed to the CPU **3**.

As shown in FIG. **2**, the RAM **5** includes a display register area ***5a*** which stores data to be displayed on the display **9**; a timekeeping register area ***5b*** which stores data on elapsed time corresponding to a signal received from the divider **2**; an area ***5c*** which stores displayed mode changing flags M, F, N, L and Q (described later); and a time register **T0** area ***5d*** which stores data on a time measured by a stopwatch.

The RAM **5** includes a first test run pace data **P1** area ***5e*** which stores data on a runner pace P1 in a first test run to be described; a first test run time **T1** area ***5f*** which stores data on a time T1 taken in the first test run; a second test run pace **P2** area ***5g*** which stores data on a runner pace P2 in a second test run to be described later; a second test run time **T2** area ***5h*** which stores data on a time T2 taken in the second test run.

In the present embodiment, the pace is meant by the number of runner steps per given time, more particularly, minute, taken when the runner ran. The test run time is meant by a time taken for the runner to run (or move through) a test distance.

In a pace-test run time relation to be described in more detail later, the RAM **5** includes an area ***5i*** which stores a coefficient a; an area ***5j*** which stores a constant b; a third test run pace **P3** area ***5k*** which stores data on a pace P3 had in the third test run; a third test run time **T3** area ***5m*** which stores data on a test time **T3** taken in the third test run; a target run time **T4** area ***5n*** which stores data on a target run time T4 aimed at when he runs any distance and keyed in by the key-in unit **10**; an area ***5p*** which stores data on a pace **P4** calculated by the CPU **3** and at which pace the runner runs in the target run time; and an area ***5q*** which stores data on a flag S indicative of the start to stop of a stopwatch function to measure the first-third test run times.

The display **9** includes a well-known liquid crystal one which is driven by the display driver **8** which receives data on the time, pace and test run time from the CPU **3** to display the data, as shown in FIG. **3**.

As shown in FIG. **3**, the pictures displayed on the display **9** include a clock display mode picture A, a first test run mode picture B, a second test run mode picture C, a third test run mode time measuring picture D and a pace setting picture E, and a real mode target run time setting picture H and a pace display picture G.

The key-in unit **10** is composed of first-sixth key switches **S1, S2, S3, S4, S5** and **S6** each of which outputs a key switch on/off signal with the first-third key switches **S1–S3** each being used for changing a mode.

The fourth key switch **S4** is used for keying in data on a pace or a target run time numerically. Each time the fourth key switch **S4** is depressed to turn on the same, the numerical value input increases. When the numerical value reaches a predetermined one, it is reset to 0, like a key switch used to key in a numerical value in a well-known digital clock.

The fifth key switch **S5** is used to start/stop the stopwatch function of the pace calculation device.

The sixth key switch **S6** is used to clear data on the time measured by the stopwatch.

The CPU **3** has the functions of displaying the time and measuring the elapsed time on the basis of a signal from the frequency divider **2**; processing a signal from the key-in unit **10**; and calculating a pace at which the runner runs any distance in a target run time.

A process for calculation of a pace by the present pace calculation device will be described with respect to FIGS. **3–5**.

When the values of the flags M and F are 0, the CPU **3** is in a time display (clock) mode. As shown in the clock mode picture A of FIG. **3**, the display **9** displays the current time, date, and day of the week (step A1 of FIG. **4**).

When a pace at which the runner runs any distance in the target run time is to be calculated, the value of the flag F is set at 1 by a signal indicative of the turning-on operation of the second key switch **S2** at the key-in unit **10** to change the operation of the CPU **3** from that in the clock mode to that in the test run mode (first or second test run mode) at step A2.

In the test run mode, a pace in the first mode test run is set and a test run time in which the runner runs any distance x at the pace is measured (step A3).

The runner keys in pace data by the fourth key switch **S4** to set the pace. As shown in the first test run picture B of FIG. **3**, the pace is set, for example, at 190 steps/minute. The pace data **P1** is stored in the first pace **P1** memory area ***5e*** of the RAM **5** of FIG. **2**. The CPU **3** outputs a pace signal to the amplifier **6** on the basis of the pace data and the speaker **7** generates a signal sound at periods of 190 steps/minute.

As shown in FIG. **5**, the runner runs a course X having any distance x at a pace corresponding to the signal sound. At the start of the course X, the runner depresses the fifth key

switch S5 to start the stopwatch function and starts to run the course to the signal sound. The runner then stops the stopwatch function by depression of the fifth key switch S5 again at the end point of the course X to measure the test run time for the course X. The test run time data obtained in this measurement is stored in the first test run time T1 area *5f* of the RAM 5. Assume now that the first run time taken is 21 seconds.

By the depression of the third key switch S3 in the test run mode, the runner changes the picture from the first test run picture B of FIG. 3 to the second test run picture C and sets a pace in a second test run and measures the test run time taken for the runner to run any distance x of the course X' are at the set pace as in the first test run (step A4).

Data on the pace set in the second test run is stored in the second pace P2 area *5g* of the RAM 5 of FIG. 2 while data on the second test run time taken for this test run is stored in the second test run time T2 area *5h* of the RAM 5.

Assume now that the pace set in the second test run was 120 steps/minute and the test run time was 46 seconds.

The test run distance in the second test run is required to be the same distance x as that in the first test run and the runner preferably makes a second test run in the same course X as that in the first test run. The pace set for the second test run is required to be different from the pace in the first test run.

The CPU 3 employs the following as a relation between a pace and test run time taken when the runner runs each of the courses X and X' having a distance x and calculates a coefficient a and a constant b of the relation:

$$P=aT+b$$

where P is the pace and T is the test run time.

The data on the paces set in the first and second test runs and data on the measured test run times are substituted into the pace P and test run time T, respectively, to establish the following simultaneous equations and the coefficient a and b are calculated:

$$190=21a+b$$

$$120=46a+b.$$

The result of solution of the simultaneous equations is a=−2.8 and b=248.8, which are then substituted into the simultaneous equations to thereby bring about the following relation:

$$P=-2.8T+248.8.$$

The coefficient a and constant b of the above relation are stored in the memory areas *5i* and *5j*, respectively, of the RAM 5. This relation is inherent in the runner who made the first and second test runs.

Next, a third test run is made. A course Y for the third test run is required to have the same distance y as that in the course Y' which the runner should run in a set target run time and is preferably the same course as Y'.

The pace employed in the third test run is set as in the first and second test runs. First, the runner depresses the first key switch S1 and then the third key switch S3 to change the picture to the pace setting picture E in the third test run mode of FIG. 3. The key switch S4 is then depressed to key in a desired pace data value, which is then stored in the third test run pace P3 area *5k* of the RAM 5 (step A5).

The runner then depresses the third key switch S3 to change the picture to the third test run mode time measuring picture D. The runner then depresses the fifth key switch S5 to fulfill the stopwatch function to measure the test run time by making a test run in the course Y. The data on the test run time T3 obtained in this measurement is stored in the third test run time T3 area *5m* of the RAM 5 (step A6).

In this case, assume that the pace set for the third test run is 180 steps/minute and the test run is 50 seconds.

Substituting "180" of the pace into the relation,

$$180=-2.8T+248.8.$$

Thus,

$$T=24.57.$$

The test run time taken for the runner to run the distance x at the pace of 180 steps/minute is obtained as 24.57 seconds from the above expression.

The runner then depresses the first key switch S1 to change the picture to the real mode target run time setting picture H and keys in target run time data with the fourth key switch S4. The target run time data is stored in the target run time T4 area *5n* of the RAM 5 (step A7).

The runner then depresses the third key switch S3 to change the picture to the real run mode pace display picture G to cause the CPU 3 to calculate the test run time taken for the runner to run the distance x at the target pace from the ratio of the target test run time (60 seconds) to the third test run time (50 seconds):

$$60:50=T:24.57.$$

Thus,

$$T=29.484.$$

Since the test run time taken for the runner to run the distance x at the same pace at which the runner runs the distance y in the target run time of 60 seconds has been obtained, the test run time is substituted into the above relation to obtain the pace P as follows:

$$P=-2.8\times29.484+248.8=166.24.$$

The pace P obtained is the one as the runner runs the distance x and which is the same pace at which the runner runs the distance y in the target run time of 60 seconds. Thus, by running the distance y at a similar pace, the target run time of 60 seconds is achieved.

Thus, the pace P=166.24 is a one calculated for the runner to run a course Y' having the distance y in the set target run time and displayed on the pace display picture G of FIG. 3 (step A8).

In order to obtain the calculated pace, it is necessary that the first and second test run distances should be the same and that the third test run distance should be the same as the real run distance in the set real target run time, but no data on the respective course distances is required to be keyed in.

When the calculated pace is obtained, data on the calculated pace is stored in the calculated pace P4 area *5p* of the RAM 5. The CPU 3 outputs a pace signal indicative of the calculated pace through the amplifier 6 to the speaker 7,

which generates a signal sound indicative of a pace of 166 steps/minute for the runner to run in the target run time of 60 seconds. Thus, the runner is able to run the course Y' to the signal sound to thereby run the course in a time similar to the target run time.

The operation of the CPU **3** on the basis of the key-in operation at the key-in unit **10**, and the mode and display picture changing operations will be described with respect to the flowchart of FIGS. **6** and **7**.

First, the flags M, F, N, L, Q which change corresponding modes in response to key-in signals and the stopwatch function flag S will be described.

The flags M, F, N, L, Q each are used for changing the picture of the display **9** and will be described with respect to FIG. **3**.

The flag M is used to change the respective clock mode (picture A), first test run mode (picture B) and second test run mode (picture C), third test run mode (pictures D, E) and real run mode (pictures H, G). The respective modes are assigned 0, 1 and 2 as the values of the flag M.

The flag F is used to change the picture from the clock mode (picture A) to the first and second test modes (pictures B, C) and vice versa when the flag M is 0. In the clock mode, F is 0; and in the first and second test run modes (pictures B, C), F=1.

The flag N is used to change the picture from one of the first and second test modes (pictures B and C,) to the other and vice versa when the flag M=0 and the flag F=1. In the first test run mode (picture B), N=0 while in the second test run mode (picture C), N=1.

The flag L changes the picture from the test run time measuring picture D to the pace setting picture E and vice versa when the flag M=1 or in the third test run mode (picture D, E). In the test run time measuring picture D, the flag L=0 while in the pace setting picture E, the flag L=1.

The flag Q changes the picture from the target run time setting picture H to the pace displaying picture G and vice versa when the flag M=2 or in the real run mode (pictures H, G). In the target run time setting picture H, the flag Q=0 while in the pace setting picture G, the flag Q=1.

When each key is depressed, the CPU **3** starts a key response process. First, when the first key switch **S1** is depressed (step B1), the CPU adds one to the value of the flag M to terminate the process (step B2). When the flag M is 3, the flag M is set at 0.

When the second key switch **S2** is depressed (step B3), the CPU **3** determines whether the value of the flag M is 0 (step B4). When the value of flag M is other than 0, the CPU **3** terminates the process. If the value of the flag M is 0, the CPU **3** determines whether the value of the flag F is 0 (step B5). If so, the CPU **3** sets the flag F at 1 (step B6). When the value of the flag F has already been 1, the CPU **3** returns the value of the flag F to 0 (step B7) and calculates the coefficient a and constant b of the relation P=aT+b by regarding the first and second test runs as completed and hence the two pace data items and corresponding test run time data items as input (step B8).

When the third key switch **S3** is depressed (step B9), the CPU **3** determines whether the value of the flag M is 0 (step B10).

If so, the CPU **3** further determines whether the value of the flag F is 1 (step B11). If not, the CPU **3** terminates the process whereas when the value of the flag F is 1, the CPU **3** determines whether the value of the flag N is 0 (step B12). If so, the CPU **3** sets 1 in the flag N to put the picture of the display **9** and the process of the CPU **3** in the second test run mode (step B13). If the value of the flag N is 1, the CPU **3** sets 0 in the flag N to put the picture of the display **9** and the process of the CPU **3** in the first test run mode (step B14).

If the flag M is other than 0, the CPU **3** determines whether the value of the flag M is 1 (step B15). If so, the picture of the display **9** and the process of the CPU **3** are in the third test run mode. Thus, the CPU **3** then determines whether the value of the flag L is 0 (step B16). If so, the CPU **3** sets 1 in the flag L to change the picture of the display **9** and the process of the CPU **3** from the time measuring picture D to the pace setting picture E in the third test run mode (step B17). If the value of the flag L is 1, the CPU **3** sets 0 in the flag L to change the picture of the display **9** and the process of the CPU **3** from the pace setting picture E to the time measuring picture D (step B18).

When the value of the flag M is neither 0 nor 1, or if the value of the flag M is 2, the picture of the display **9** and the process of the CPU **3** are in the real run mode. Thus, the CPU **3** determines whether the value of the flag Q is 0 (step B19). If so, the CPU **3** terminates the third test run process and determines that the third test run pace data and test run time data have been input and that the target run time data has been input. The CPU **3** thus sets 1 in the flag Q and changes the picture of the display **9** and the process of the CPU **3** from the target run time setting picture H to the pace display picture G in the real run mode (step B20), calculates the pace and display it on the display **9** (step B21).

When the value of the flag Q is other than 0, the value of the flag Q is set at 0, and the picture of the display **9** and the process of the CPU **3** are changed from those in the pace calculating mode to those in the target run time inputting mode to terminate the key response process (step B22).

When the fourth key switch **S4** is depressed (step B23), a numerical value for setting a pace is keyed in when the picture of the display **9** and the process of the CPU **3** are in any one of the first-third test run modes (M=0 or 1) while a numerical value for setting a target run time is input in the real run mode (M=2)(step B24).

When the fifth key switch **S5** is depressed (step B25), the CPU **3** first determines whether the value of the flag M is 0 and the value of the flag F is 1 (step B26). If so, the CPU **3** determines whether the value of the flag S is 1 (step B27) and then whether the value of the flag N is 0 (step B28).

When the value of the flag N is 0, the first test run mode has been employed. Thus, the CPU **3** performs the process in the first test run mode. If the flag S is other than 1, that is, if S is 0, the stopwatch function has been stopped. Thus, the CPU **3** sets 1 in the flag S to start the stopwatch function (to count up the value of the time register **T0** of the RAM **5** one by one at intervals of 1/32 seconds in accordance with a signal from the frequency divider **2**) and terminates the key response process (step B29).

When the flag S is 1, the stopwatch function has been already operated. Thus, the CPU **3** sets 0 in the flag S to stop the stopwatch function (step B30), and stores the time register **T0** data, stored in the memory area **5*d*** of the RAM **5**, in the first test run time **T1** area **5*f*** of the RAM **5** and terminates the key response process (step B31).

When the flag N is 1, the second test run mode has been employed. Thus, the CPU **3** sets 0 in the flag S (step B32) and performs a process in the second test run mode similar to that in the first test run mode. The data stored in the time register **T0** area **5*d*** of the RAM **5** is stored in the second test run time **T2** area **5*h*** of the RAM **5** (step B33).

When the value of the flag M is not 0 and the value of the flag F is not 1 either, the CPU **3** determines whether the value of the flag M is 1 and the value of the flag L is 0 (step B34). If the value of the flag M is not 1 and the value of the

flag L is not 0, the CPU 3 terminates the process. When the value of the flag M is 1 and the value of the flag L is 0, the CPU 3 determines whether the value of the flag S is 1 (step B35) to perform the process in the third test run mode.

When the value of the flag S is not 1, the CPU 3 sets 1 in the flag S to start the stopwatch function (step B29) to measure a test run time in the third test run. When the value of the flag S is 1, the stopwatch function has been operated. Thus, the CPU 3 sets 0 in the flag S to stop the stopwatch function (step B36), stores time register T0 data, stored in the memory area 5d of the RAM 5, as data on a third run test run time in the third test run time T3 area 5m of the RAM 5 to thereby terminate the key response process (step B37).

When the depressed key is not any of the first-fifth key switches S1–S5, the sixth key switch S6 has been operated. Thus, the time data measured by the stopwatch function is cleared or the data value in the time register T0 of the RAM 5 is reset to 0 to terminate the process (step B38).

First, the whole operation of the pace calculation device of this embodiment having the clock function will be described below with respect to the flowchart of FIG. 7.

First, when timing signals are input from the divider 2 at intervals of 1/32 seconds to the CPU 3 which is in the halt state (step C1), the CPU 3 performs a clocking process which sequentially records the time in a well-known manner (step C2). The CPU 3 then determines whether the flag S indicative of the start/stop of the stopwatch function is 1 (step C3). If so, or when the stopwatch function is in operation, the CPU 3 counts up the time register T0 value by one in response to a signal generated from the frequency divider 2 at an interval of 1/32 seconds (step C4).

A sounding process for generation of a signal sound (step C5) starts. In this process, a signal sound is generated in correspondence to a pace set in the first-third test run modes or calculated in the real run mode. Each time the time indicative of the pace duration has passed, the CPU 3 outputs a pace signal to the amplifier 6, and the speaker 7 hence generates a signal sound corresponding to the pace signal.

A numerical value changed due to a lapse of time and the operation of the stopwatch function is displayed on the display 9 (step C6).

When a signal from the key-in unit 10 is input to the CPU 3 which is in the halt state (step C1), the key-in response operation is performed as an interrupt process and the corresponding mode is displayed on the display 9 (step C7).

According to this pace calculation device, the runner makes a test run at a preset pace to draw a relation inherent in the runner between pace and test run time to calculate a pace corresponding to a target run time.

By making a test run through each of the courses X and X' of the same distance x, the relation is obtained and especially no data on the distance of the courses X and X' is required to be input. The first and second test runs in the same course X do not require the distance of the course X to be known as on a ground for athletic sports and the relation can be obtained for any regular running course.

A runner makes a third test run along a course Y having the same distance as a course Y' which the runner should run in a target run time; a set pace in the third test run is introduced into the relation to obtain a test run time at the set pace in the third test run in the distance x of the first and second test runs; the test run time is multiplied by the ratio of the target run time to the third test run time to calculate a time taken for the runner to run the distance x at a pace at which the runner runs a distance y in the target run time; and data on this time is substituted into the relation to obtain a pace at which the runner runs the distance y in the target run time.

The distance x of the first and second test run courses to obtain the above relation is not required to be the same as the distance y for a run in the target run time. Once the relation is obtained for one runner, a pace at which the runner runs in a target run time in each of a plurality of courses each having a different distance can be calculated by using the relation and causing the runner to make a third test run only once in that course.

Even when a second target run time is set and a corresponding pace is calculated in a course different from that for which the first target run time is set first, no data on the distance of the second course is required to be input.

Thus, according to the pace calculation device of this embodiment, a pace corresponding to a target run time is easily calculated even in a course whose distance is not known. Once the expression is obtained, a pace corresponding to a target run time is more easily calculated in each of a plurality of courses each having a different distance.

Since no data on the distance of a course and the length of a runner step is required to be set, the device is easily used anywhere and a pace is calculated accurately. Thus, pace data is only required to be input in a test run and target run time data is required to be input in a real run, so that the key-in operation is simple and the device is easy to use.

Second Embodiment

A second embodiment of the pace calculation device according to the present invention will be described with reference to the drawings. This pace calculation device is incorporated into an electronic wrist watch like the pace calculation device of the first embodiment.

The pace calculation device of this second embodiment is different from that of the first embodiment in that the former automatically sets a runner pace for the runner at the start of each of first-third test runs whereas the latter sets a runner pace in accordance with data keyed in from the key-in unit 10 in each of the first-third test runs. To this end, the pace calculation device of the second embodiment has the functions of detecting the number of runner steps in the first-third test runs and calculating a runner pace in each of the first-third test runs on the basis of the detected number of steps.

The pace calculation device of the second embodiment is similar to the pace calculation device of the first embodiment in that predetermined data is obtained in the first-third test runs to obtain a relation and a pace is obtained in a real run for which the target time is determined from the relation.

FIG. 8 is a block diagram indicative of the basic structure of the pace calculation device of the second embodiment. In FIG. 8, reference numeral 101 denotes an oscillator; 102, a frequency divider; 103, a CPU; 104, a ROM; 105, a RAM; 106, an amplifier; 107, a speaker; 108, a display driver; 109, a display; 110, a key-in unit; 111, a pedometer. Those elements of the second embodiment are the same in structure as those of the first embodiment except for the pedometer 111.

As shown in FIG. 8, the pedometer 111 is composed of an acceleration sensor 112, a waveform shaper 113 and a counter 114. The acceleration sensor 112 is a well-known one, which is composed, for example, of a plate-like piezoelectric element fixed at one end in a casing and having two leads, one attached to each of the opposite surfaces of the plate-like piezoelectric element. When vibrations due to

walking or running are applied to the acceleration sensor **112**, the piezoelectric element vibrate in a direction perpendicular to the surfaces thereof to produce pulsating voltages, which are obtained from the leads attached to the opposite surfaces of the elements for sensing purposes.

The waveform shaper **113** shapes the pulsating waveforms obtained from the acceleration sensor **112** to output a square pulse signal. The waveform shaper **113** is composed of a low pass filter, an amplifier and an operational amplifier (not shown). In the waveform shaper **113**, high frequency components of a signal from the acceleration sensor **112** are filtered out and the filtered signal is output through the amplifier to the operational amplifier, which outputs an accurate pulse signal corresponding to walking and running to the counter **114**.

The counter **114** counts pulse signals from the waveform shaper **113** and outputs the result of the counting to the CPU **103**.

During detection of the number of steps in the test run mode, the pulse signal from the waveform shaper **113** is input to the CPU **103**, which feeds a pace signal corresponding to the pulse signal to the amplifier **106** such that the speaker **107** outputs a signal sound corresponding to the pulse signal from the waveform shaper **113** or to the number of runner's steps.

FIG. **9** shows the structure of the RAM **105**. In FIG. **9**, reference numeral **105*a*** denotes a display register area which stores data displayed on the display **109**; **105*b***, a timekeeping register area which stores data on lapsed time corresponding to the input signal from the frequency divider **102**; **105*c***, an area which stores display mode changing flags M', F', N', Q' to be described later; **105*d***, a time register T'0 which stores data on the time measured by a stopwatch function; **105*e***, a first test run pace P'1 area which stores data on a pace in the first test run; **105*f***, a first test run time T'1 area which stores data on a test run time taken in the first test run; **105*g***, a second test run pace P'2 area which stores data on a pace in the second test run; **105*h***, a second test run time T'2 area which stores data on the test run time taken in the second test run.

In the present embodiment, the pace is meant by the number of runner steps per given time, more particularly, minute, at which the runner runs. The test time is meant by a time taken for the runner to run a test distance.

In the pace-test run time relation to be described later, reference numerals **105*i*** and **105*j*** denote an area which stores a coefficient a' and an area which stores a constant b', respectively; **105*k***, a third test run pace P'3 area which stores data on a pace in a third test run; and **105*m***, a third test run time T3 area which stores data on a test time taken in the third test run.

Reference numerals **105*n***, **105*p*** and **105*q*** denote first, second and third numbers-of-steps PE1, PE2, and PE3 areas which store corresponding data items on the numbers of steps detected by the pedometer **111** in the first-third test runs, respectively.

Reference numeral **105*r*** denotes a target run time T'4 area which stores data on a target run time keyed in by the key in unit **110**; **105*s***, a calculated pace P'4 area which stores data on a pace calculated by the CPU **103** and at which the runner runs in the target run time; and **105*t***, an area which stores data on a flag S' indicative of the start to stop of the stopwatch function to measure each of the run times taken in the first-third test runs and of the function of detecting the number of steps taken for the runner to run.

The first test run pace P'1 area **105*e***, second test run pace P'2 area **105*g*** and test run pace P'3 area **105*k*** store data items on the paces in the first, second and third test runs calculated by the CPU **103** on the basis of data items on the numbers of steps PE1, PE2, PE3 stored in the first, second and third test run numbers-of-steps PE1, PE2 and PE3 areas **105*n***, **105*p*** and **105*q*** and data items on the first, second and third test run times stored in the first, second and third test run time T'1, T'2 and T'3 areas **105*f***, **105*h*** and **105*m***, respectively.

As shown in FIG. **10**, the pictures displayed on the display **109** include a clock display mode picture A', a first test run mode picture B', a second test run mode picture C', a third test run mode timekeeping picture D', a real run mode target run time setting picture H' and a pace display picture G'.

The key-in unit **110** is composed of first-sixth key switches S'1, S'2, S'3, S'4, S'5 and S'6 each of which outputs a key switch on/off signal with first-third key switches S'1–S'3 each being used for changing a mode.

The fourth key switch S'4 is used for keying in numerical data on a target run time. Each time the fourth key switch S'4 is depressed to be turned on, the numerical value input increases until the numerical value reaches a predetermined one, whereupon it is reset to 0, like a key switch used to key in a numerical value into a well-known digital clock.

The fifth key switch S'5 is used to start/stop the stopwatch function and pedometer function of the pace calculation device.

The sixth key switch S'6 is used to clear the data measured and detected by the stopwatch function and pedometer function.

The CPU **103** has the functions of recording and measuring the time and elapsed time on the basis of a signal from the frequency divider **102**, processing data keyed in from the key-in unit **110**, and calculating runner's paces in the first-third test runs and a pace at which the runner runs any distance in a target run time.

A process for calculating a pace by the pace calculation device of the second embodiment will be described with respect to the flowchart of FIG. **11** and FIGS. **10** and **5**.

When the values of the fags M' and F' are 0, the CPU **103** is in the time display (clock) mode. As shown in the clock mode picture A' of FIG. **10**, the display **109** displays the current time, date, and day of the week (step D1 of FIG. **11**).

When a pace at which the runner runs any distance in the target run time is to be calculated, the flag F' is set at 1 by an on signal from the second key switch S'2 at the key-in unit **110** to change the process of the CPU **103** from that in the clock mode to that in a test run mode (first and second test run modes) at step D2.

In the test run mode the number of steps taken for the runner to run a course X of any distance x in the first mode test run is detected and a test run time taken for the runner to run that course X at a given pace is measured. A pace for the first test run is calculated on the basis of the detected number of steps and the measured test run time (step D3).

Data on the number of steps counted in the first test run is displayed on the first test run mode number-of-steps detecting picture B' of FIG. **10**. Both the number-of-steps detecting function and the stopwatch function are started simultaneously by the depression of the fifth key switch S'5 when the first test run starts. However, the time measured by the stopwatch is not displayed on the display.

When the pedometer function starts, the pedometer **111** generates a voltage waveform depending on the number of steps of the runner and feeds to the CPU **103** a pulse signal composed of a shaped version of the voltage waveform. In

response to the pulse signal, the CPU **103** outputs a pace signal to the amplifier **106**, and hence the speaker **107** generates a signal sound accordingly. As shown in FIG. **5**, the runner starts to run a course X of a distance x to the signal sound. When the runner ends running the course X, he again depresses the fifth key switch S'**5** to stop the stopwatch function and the number of steps detecting function. Thus, data on the total number of steps taken in the first test run through the course X counted by the counter **114** is sent to the CPU **103** and stored in the first test run number-of-steps PE**1** area **105***n* of the RAM **105**. Data on the test run time stored in the time register T'**0** is stored in the first test run time T'**1** area **105***f* of the RAM **105**. The CPU **103** calculates a pace in the first test run on the basis of those data items and stores data on the calculated pace in a first test run pace P'**1** area **105***e* of the RAM **105**.

Assume now that, for example, the detected number of steps is 66 and the measured test run time is 20 seconds. Thus, the pace is, for example, 198 steps/minute.

It is important that the runner runs any distance x at a given pace in the first test run. This applies in the second and third test runs. The runner can adjust his pace to a signal sound from the speaker **107**, as mentioned above.

By the depression of the third key switch S'**3** in the test run mode, the picture is changed from the first test run picture B' of FIG. **10** to the second test run C'. As in the first test run, the number of steps required when the runner runs a course X' of any distance x in the second test run is detected and the time taken for the runner to run the distance x at a fixed pace is measured, and a pace in the second test run is calculated on the basis of the detected number of steps and the measured test run time, as in the first run (step **D4**).

Data on the number of steps detected in the second test run is stored in the second number of steps PE**2** area **105***p* of the RAM **105** while data on the test run time is stored in the second test run time T'**2** area **105***h* of the RAM **105**. The CPU **103** calculates a pace in the second test run on the basis of those data items and stores data on the calculated pace in a second pace P'**2** area **105***g* of the RAM **105**.

Assume now that the number of steps taken is 92, the test run time taken is 46 seconds and the calculated pace is 120 steps/minute, as the result of the second test run.

The test run distance in the second test run is required to be the same distance x as that in the first test run and the runner preferably makes a second test run in the same course X as in the first test run. The pace set for the second test run is required to be different from the pace in the first test run.

The CPU **103** employs the following as the relation between a pace which the runner had and a test run time taken for the runner to run when the runner runs each of the courses X and X' of a distance x, and calculates a coefficient a' and a constant b' of the relation:

$$P'=a'T'+b'$$

where P' is the pace and T' is the test run time.

The data on the paces and on the test times obtained in the first and second test run are substituted into the pace P' and test run time T' to establish the following simultaneous equations and then calculates the coefficient a' and constant b':

$$198=20a'+b'$$

$$120=46a'+b'.$$

As the result of solution of the simultaneous equations, a'=−3 and b'=258, and the relation is given as

$$P'=-3T'+258.$$

The coefficient a' and constant b' of the above relation are stored in the memory areas **105***i* and **105***j*, respectively, of the RAM **105**, respectively. This relation is inherent in the runner who made the first and second test runs.

Next, the runner makes a third test run. The first key switch S'**1** is depressed to change the picture on the display to a third test run mode timekeeping picture D' of FIG. **10**. Under such conditions, the runner depresses the fifth key switch S'**5** at the starting and ending points of a course Y of a distance y to start and stop the stopwatch and number-of-steps detecting functions simultaneously to thereby detect and measure the number of steps and test run time, respectively, taken when the runner runs the course Y at a given pace in the third test run, in a manner similar to those in the first and second test runs. A pace in the third test run is then calculated on the basis of the detected number of steps and the measured test run time (step **D5**).

By depression of the fifth key switch S'**5** in the third test run mode timekeeping picture D' of FIG. **10**, the measured time is displayed on the display. At this time, the detected number of steps taken is not displayed on the display, but the number of steps is detected simultaneously by depression of the fifth key switch S'**5** on the timekeeping picture D'.

The data on the number of steps measured in the third test run is then stored in the third number-of-steps PE**3** area **105***q* of the RAM **105** and data on the test run time is stored in the third test run time T'**3** area **105***m* of the RAM **105**. The CPU **103** calculates a pace in the third test run on the basis of those data items and stores data on the calculated pace in the third test run pace P'**3** memory area **105***k* of the RAM **105**.

In this case, assume that the number of steps taken is 150, the test run time taken is 50 seconds and the pace is 180 steps/minute as the result of the third test run.

Substituting "180" of the pace into the relation,

$$180=-3T'+258.$$

Thus,

$$T'=26.$$

The test run time taken for the runner to run the distance x at the pace of 180 steps/minute is 26 seconds, as obtained from the above relation.

The first key switch S'**1** is then depressed to change the picture to the real mode target run time setting picture H', and the fourth key switch S'**4** is depressed to key in data on a target run time taken for the runner to run a course Y' of the same distance y as that in the third test run (step **D6**).

Data on the target run time is stored in a target run time T'**4** area **105***r* of the RAM **105**.

The third key switch S'**3** is then depressed to change the picture to the real run mode pace display picture G' and the test run time taken for the runner to run the distance x at the target pace is calculated from the ratio of the third test run time (50 seconds) to the target test run time (60 seconds):

$$60:50=T'':26.$$

Thus,

$T'=31.2.$

Since the test time taken for the runner to run the distance x at the same pace as the runner runs the distance y in the target run time of 60 seconds has been obtained, the test run time is substituted into the above relation to obtain the pace P':

$$P'=-3\times31.2+258=164.4.$$

The pace P' obtained is a one at which the runner runs the distance x and is the same pace at which the runner runs the distance y in the target run time of 60 seconds. Thus, by running the distance y at the same as the pace P', the target run time of 60 seconds is achieved.

Thus, the pace P'=164.4 is a one calculated to run a course Y' of a distance y for which the target run time is set, and is displayed on the pace display picture G' of FIG. **10** (step D7).

In order to obtain the calculated pace, it is necessary that the first and second test run distances are the same and that the third test run distance is the same as the real run distance for which the real target run time is set, but data on the respective course distances is not required to be keyed in.

When the calculated pace is obtained, data on the calculated pace is stored in the calculated pace P'**4** area **105***s* of the RAM **105**. The CPU **103** outputs a pace signal indicative of the calculated pace through the amplifier **106** to the speaker **107**, which generates a signal sound indicative of a pace of 164 steps/minute at which the runner runs in the target run time of 60 seconds. Thus, the runner is able to run the course Y' to the signal sound to thereby run the course in a time close to the target run time.

A process responsive to the key-in operation at the key-in unit **110**, the mode changing operation and the display picture changing operation, performed actually by the CPU **103**, will be described with respect to the flowcharts of FIGS. **12** and **13**.

First, the flags M', F', N' and Q' which change the modes in response to keyed-in data and the stopwatch and pedometer function flag S' will be described.

The flags M', F', N' and Q' each are also used for changing the picture of the display **109** and will be described with respect to FIG. **10**.

The flag M' is used to change the respective clock mode (picture A'); first test run mode (picture B') and second test run mode (picture C'); third test run mode (picture D'); and real run mode (pictures H', G'). The respective modes are assigned 0, 1 and 2 as the value of the flag M'.

The flag F' is used to change the picture from the clock mode (picture A') to the first and second test modes (pictures B', C') and vice versa when the value of the flag M' is 0. In the clock mode, the value of the flag F' is 0; and in the first and second test run modes (pictures B', C'), the value of the flag F'=1.

The flag N' is used to change the picture from one of the first and second test modes (pictures B' and C') to the other and vice versa when the value of the flag M'=0 and the value of the flag F'=1. In the first test run mode (picture B'), N'=0 while in the second test run mode (picture C'), N'=1.

The flag Q' is used to change the picture from the target run time setting picture H' to the pace displaying picture G' and vice versa in the real run mode when the flag M'=2 or in the real run mode (picture H', G'). In the target run time setting picture H', the value of the flag Q'=0 while in the pace displaying picture G', the value of the flag Q'=1.

When each key is depressed, the CPU **103** starts a key response process. First, when the first key switch S'**1** is depressed (step E**1**), the CPU **103** determines whether the value of the flag M' is 0 (step E**2**). If so, the CPU **103** sets 1 in the flag M' to put the picture of the display **109** and the process of the CPU **103** in the third test run mode (step E**3**). If the value of the flag M' is other than 0, the CPU **103** adds one to the value of the flag M' to terminate the process (step E**4**). When the value of the flag M' reaches 3, the value of the flag M' is set at 0.

When the second key switch S'**2** is depressed (step E**5**), the CPU **103** determines whether the value of the flag M' is 0 (step E**6**). When the value of the flag M' is other than 0, the CPU **103** terminates the process. If the value of the flag M' is 0, the CPU **103** determines whether the value of the flag F' is 0 (step E**7**). If so, the CPU **103** sets 1 in the flag F' (step E**8**). If the value of the flag F' is 1, the CPU **103** returns the value of the flag F' to 0 (step E**9**) and calculates the coefficient a' and constant b' of the relation P'=a'T'+b' by regarding the first and second test runs as completed and hence the two pace data items and test run time data items as obtained (step E**10**).

When the third key switch S'**3** is depressed (step E**11**), the CPU **103** determines whether the value of the flag M' is 0 (step E**12**).

If so, the CPU **103** further determines whether the value of the flag F' is 1 (step E**13**). If not, the CPU **103** terminates the process. If the value of the flag F' is 1, the CPU **103** determines whether the value of the flag N' is 0 (step E**14**). If so, the CPU **103** sets 1 in the flag N' and puts the picture of the display **109** and the process of the CPU **103** in the second test run mode (step E**15**). If the value of the flag N' is 1, the CPU **103** sets 0 in the N' and puts the picture of the display **109** and the process of the CPU **103** in the first test run mode (step E**16**).

If the value of the flag M' is other than 0, the CPU **103** determines whether the value of the flag M' is 1 (step E**17**). If so, the CPU **103** terminates the process.

If the value of the flag M' is other than 0 or 1, or the value of the flag M' is 2, the picture of the display **109** and the process of the CPU **103** are in the real run mode. Thus, the CPU **103** determines whether the value of the flag Q' is 0 (step E**18**). If so, the CPU **103** determines that the third test run has ended and determines that pace data and test run time data in the third test run have been set or input and that target run time data has been input, sets 1 in the flag Q' to change the picture of the display **109** and the process of the CPU **103** from the target run time setting picture H' to the pace displaying picture G' in the actual run mode (step E**19**), calculates the pace and displays it on the display **109** (step E**20**).

If the value of the flag Q' is other than 0, the CPU **103** sets 0 in the flag Q' to change the picture of the display **109** and the process of the CPU **103** from the pace calculating mode to the target run time inputting mode to thereby terminate the process (step E**21**).

When the fourth key switch S'**4** is depressed (step E**22**), a numerical value for setting a target run time is input when the picture of the display **109** and the process of the CPU **103** are in the real run mode (M'=2) (step E**23**).

When the fifth key switch S'**5** is depressed (step E**24**), the CPU **103** first determines whether the value of the flag M' is 0 and the value of the flag F' is 1 (step E**25**). If so, the CPU **103** determines whether the value of the flag S' is 1 (step E**26**) and then whether the value of the flag N' is 0 (step E**27**).

When the value of the flag N' is 0, the first test run mode has been employed. Thus, the CPU **103** performs a process

in the first test run mode. If the value of the flag S' is other than 1, that is, 0, the stopwatch function has been stopped. Thus, the CPU **103** sets 1 in the flag S' to start the stopwatch function which includes counting up the value of the time register T'**0** of the RAM **105** in accordance with a signal from the frequency divider **102** one by one at intervals of 1/32 seconds, and terminates the key response process (step **E28**).

When the flag S' is 1, the stopwatch function and number-of-steps detecting function have been already operated. Thus, the CPU **103** sets 0 in the flag S' to stop the stopwatch function and the number-of-steps detecting function (step **E29**), stores data in the time register T'**0** as data on a first test run time in the first test run time T'1 area of the RAM **105**, stores count data on the number of steps in the counter **114** of the pedometer **111** as data on the number-of-steps in the first test run number-of-steps PE1 area **105***n* of the RAM **105**, calculates a pace P'**01** on the basis of those stored data items on the number of steps and test run time, and stores data on the calculated pace P'**01** in the first test run pace P'**1** area **105***e* of the RAM **105** and terminates the process (step E30).

When the value of the flag N' is 1, the second test run mode has been employed. Thus, the CPU sets 0 in the flag S' (step E31) and performs a process in a second test run mode similar to that in the first test run mode. The CPU **103** stores data in the time register T'**0** as data on a second test run time in the second test run time T'2 area **105***h* of the RAM **105** and also stores count data on the number of steps in the counter **114** of the pedometer **111** as data on the number-of-steps in the second test run number-of-steps PE2 area **105***p* of the RAM **105**, calculates a pace P'**02** on the basis of those stored data items on the number of steps and the test run time, stores it in the second test run pace P'2 area **105***g* of the RAM **105**, and terminates the process (step E32).

When the value of the flag M' is not 0 and the flag F' is not 1 either, the CPU **103** determines whether the value of the flag M' is 1 (step E33). If the value of the flag M' is other than 1 or 0, the CPU **103** terminates the process. When the flag M' is 1, the CPU **103** determines whether the value of the flag S' is 1 (step E34) to perform a process in the third test run mode.

When the value of the flag S' is not 1, the CPU **103** sets 1 in the flag S' to start the stopwatch function and the number-of-steps detecting function (step E28) to measure a test run time and detect the number of steps in the third test run. When the value of the flag S' is 1, the CPU **103** sets 0 in the flag S' to stop the stopwatch function and the number-of-steps detecting function to terminate the measurement of the test run time and the detection of the number of steps in the third test run (step E35). Thus, the CPU **103** stores data on the time register T'**0** as data on a third run time in the third test run time T'**3** area **105***m* of the RAM **105**, stores count data on the number of steps in the counter **114** of the pedometer **111** as count data on the number of steps in the number-of-steps PE3 area **105***q* of the RAM **105**, calculates a pace P'**03** on the basis of those stored data items on the number of steps and test run time and stores it in the third test run pace P'**3** area **105***k* of the RAM **105** and terminates the process (step E36).

When the depressed key is not any of the first-fifth key switches **S1'**–**S5'**, the sixth key switch **S6'** has been operated. Thus, the CPU **103** clears the data in the time register T'**0** of the RAM **105**, and data on the first-third test run numbers of steps PE1–PE3 in the areas **105***n*–**105***q*, and also clears the data in the counter **114** of the padometer **111** to terminate the process (step E37).

Referring next to the flowchart of FIG. **13**, the whole operation of the pace calculation device of this embodiment having the clock function will be described below.

First, when timing signals are input from the divider **102** at intervals of 1/32 seconds to the CPU **103** which is in the halt state (step F1), the CPU **103** performs a clocking process which records the time subsequently in a well-known manner (step F2). The CPU **103** then determines whether the value of the flag S' indicative of the start/stop of the stopwatch function is 1 (step F3). If so, or when the stopwatch function is in operation, the CPU **103** counts up the value of the time register T'**0** by one in response to a signal generated from the frequency divider **102** at an interval of 1/32 seconds (step **F4**).

A sounding process for generation of a signal sound (step F5) starts. In this process, a signal sound is generated in each of the first-third test runs and the real run. Each time a period of time indicative of the pace calculated in the real run mode has passed in the real run, the CPU **103** outputs a pace signal to the amplifier **106** and the speaker **107** generates a corresponding signal sound. In the first-third test runs, a pulse signal based on a detection signal from the acceleration sensor **112** of the pedometer **111** is input to the CPU **103** and hence the speaker **107** outputs a signal sound correspondingly.

A numerical value changed due to a lapse of time or the operation of the stopwatch function is displayed on the display **109** (step **F6**).

When a signal from the key-in unit **10** is input to the CPU **103** which is in the halt state (step F1), the CPU **103** performs the key response operation as an interrupt process and displays the corresponding mode on the display **109** (step F7).

Thus, according to the pace calculation device of the second embodiment, a pace corresponding to a target run time is easily calculated even for a course whose distance is unknown, as in the first embodiment. Once a pace-target time relation inherent in the runner is obtained, a pace is easily calculated which corresponds to a target run time for each of a plurality of courses each having a different distance.

Since no data on the distance of a course and a runner step is required to be set, the device is easily used anywhere to calculate an accurate pace.

According to the pace calculation device of the second embodiment, the number of runner steps is detected by the pedometer in each of the first-third test runs, and a pace in each of the first-third test runs is calculated on the basis of the detected number of steps in that test run. Thus, pace data is not required to be keyed in as is in the pace calculation device of the first embodiment. Target run time data is only required to be keyed in, so that the data key-in operation is simpler. Thus, the pace calculation device of the second embodiment is easier to use than in the pace calculation device of the first embodiment.

The pace calculation devices according to the present invention are usable not only in the case of the running for which the embodiments have been illustrated, but also in the case of walking and jogging.

What is claimed is:

1. A pace calculation device comprising:

first storage means for storing data on a plurality of different paces at each of which a person moves through any first distance and data on a like number of different times each taken for the person to move through the first distance at a respective one of the paces;

second storage means for storing data on any pace at which the person moved through any second distance and data on a time taken for the person to move through the second distance;

third storage means for storing data on a target movement time taken for the person to move through the second distance at any pace; and

calculating means for calculating a pace at which the person moves through the second distance in the target movement time, based on data on which is stored in said third storage means, on the basis of the data on a plurality of paces and the data on a like number of movement times stored in said first storage means, and the data on the pace and data on the movement time stored in said second storage means.

2. A pace calculation device according to claim **1**, wherein the data on the pace includes data on the number of steps per minute.

3. A pace calculation device comprising:

first input means for inputting to the device data on a plurality of different paces at each of which a person moves through any first distance and data on a pace at which the person moves through any second distance;

second inputting means for inputting to the device data on a target movement time in which the person moves through the second distance at any pace;

timekeeping means for measuring movement times taken for the person to move through the first and second distances on the basis of the data on the respective paces inputted by said first inputting means to provide data on the movement times;

storage means for storing the data on a plurality of paces inputted by said first inputting means, the data on a target movement time inputted by said second inputting means the data on the movement times provided by said timekeeping means;

calculating means for drawing a relation between a pace and a movement time on the basis of the data on the movement times and the data on the paces for the movement of the person through the first distance, and calculating from the relation a pace at which the person moves through the second distance in the target movement time, based on data on which is inputted by said second input means; and

sounding means for generating a signal sound corresponding to the pace calculated by said calculating means.

4. A pace calculation device according to claim **3**, wherein said calculating means obtains a relation inherent in the person on the basis of data on at least two movement times each taken for the person to move through the first distance and stored in said storage means and data on at least two paces of the person involved in the measurement of the movement times.

5. A pace calculation device according to claim **3** or **4**, wherein said calculating means calculates a pace required for the person to move through the second distance in the target movement time, data on which is stored in said storage means, on the basis of the relation and data on the time movement and data on the pace for movement of the person through the second distance stored in said storage means.

6. A pace calculation device according to claim **3** or **4**, wherein the movement of the person through each of the first and second distances comprises a run.

7. A pace calculation device according to claim **3** or **4**, wherein the data on the pace comprises data on the number of steps per minute.

8. A pace calculation device according to claim **3** or **4**, wherein said timekeeping means comprises a stopwatch.

9. A pace calculation device according to claim **3** or **4**, wherein said sounding means generates a signal sound corresponding to data on the pace calculated by said calculating means and a signal sound corresponding to data on the pace inputted by said first input means.

10. A pace calculation device according to claim **3** or **4**, further comprising display means for displaying the value of the pace calculated by said calculating means.

11. A pace calculation device comprising:

pedometer means for detecting the number of steps taken for a person to move through any first distance at each of a plurality of different paces and the number of steps taken for the person to move through any second distance at any pace;

timekeeping means for measuring the times taken for the person to move through the respective first and second distances when the respective numbers of steps are detected by said pedometer means;

input means for inputting to device data on a target movement time taken for the person to move through the second distance;

first calculating means for calculating a plurality of paces at each of which the person moved through the first distance and a pace at which the person moved through the second distance on the basis of data on the numbers of steps obtained from said pedometer means and data on the movement times obtained from said timekeeping means;

storage means for storing data on the plurality of paces obtained from said first calculating means, data on the target movement time inputted by said input means, and data on the plurality of movement times obtained from said timekeeping means;

second calculating means for drawing a relation between a pace and a movement time on the basis of data on the plurality of paces and data on the plurality of movement times taken for the person to move through the first distance stored in said storage means, and calculating from the relation a pace at which the person moves through the second distance in the target movement time, based on data on which is input by said second input means; and

sounding means for generating a signal sound in correspondence to the pace calculated by said second calculating means.

12. A pace calculation device according to claim **11**, wherein said second calculating means obtains a relation inherent in the person on the basis of data on at least two movement times each taken for the person to move through the first distance and stored in said storage means and data on at least two paces of the person involved in the measurement of the movement times.

13. A pace calculation device according to claim **11** or **12**, wherein said second calculating means calculates a pace required for the person to move through the second distance in the target movement time, data on which is stored in said storage means, on the basis of the relation and data on the time movement and data on the pace for movement of the person through the second distance stored in said storage means.

14. A pace calculation device according to claim **11** or **12**, wherein the movement of the person through each of the first and second distances comprises a run.

15. A pace calculation device according to claim **11** or **12**, wherein the data on the pace comprises data on the number of steps per minute.

16. A pace calculation device according to claim **11** or **12**, wherein said timekeeping means comprises a stopwatch.

17. A pace calculation device according to claim **11** or **12**, wherein said sounding means generates a signal sound corresponding to data on the pace calculated by said second calculating means and a signal sound corresponding to the pace at which the person moves when said pedometer means detects the number of steps taken.

18. A pace calculation device according to claim **11** or **12**, further comprising display means for displaying the value of the pace calculated by said second calculating means.

* * * * *

Evidence Appendix C (37 C.F.R. § 41.37(c)(1)(ix))
U.S. Patent No. 5,771,399 to Fishman

This patent was originally made of record and relied upon by the Office in the First Office Action mailed February 20, 2004.

US005771399A

United States Patent [19]

Fishman

[11] **Patent Number: 5,771,399**

[45] **Date of Patent: Jun. 23, 1998**

[54] **OPTICAL WAND HAVING AN END SHAPED TO REGISTER TO THE SURFACE OF A PORTABLE DEVICE TO ALIGN RESPECTIVE OPTICAL ELEMENT PAIRS FOR DATA TRANSFER**

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[73] Assignee: **Microsoft Corporation**, Redmond, Wash.

[21] Appl. No.: **669,783**

[22] Filed: **Jun. 26, 1996**

[51] **Int. Cl.**^{6} **G06F 13/00**

[52] **U.S. Cl.** **395/892**; 395/882; 395/200.57; 364/708.1; 368/47; 428/162

[58] **Field of Search** 395/892, 882, 395/200.57; 250/227.13; 341/13; 235/472; 428/162; 368/47; 364/708.1

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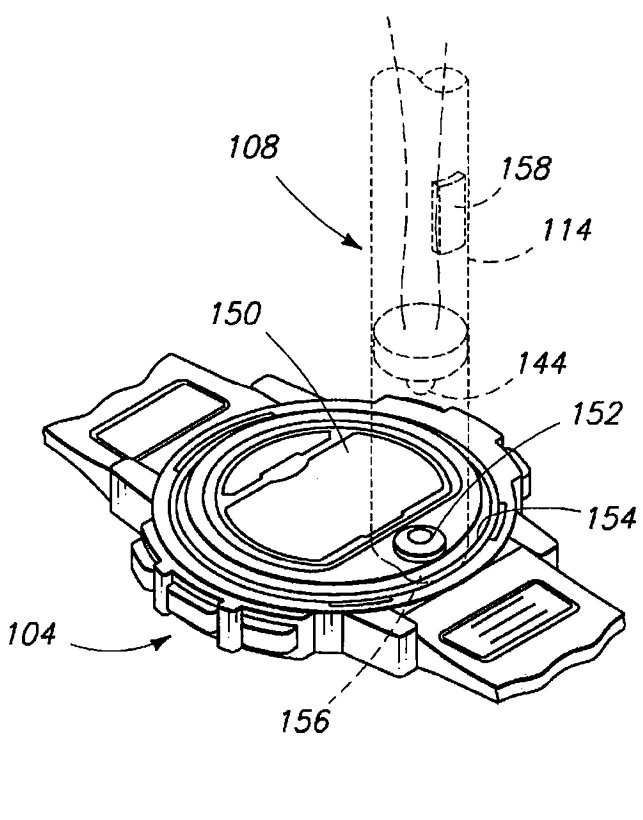
Primary Examiner—Thomas C. Lee
Assistant Examiner—Ki S. Kim
Attorney, Agent, or Firm—Lee & Hayes, PLLC

[57] **ABSTRACT**

Described herein is a system for transferring a binary data stream in a serial edge-based transmission format between a computer and a portable device such as the Timex® Data-Link™ watch. In the edge-based format expected by the Data-Link™ watch, individual data bits have first and second binary values which are represented by the presence or absence of signal edges at mark times which occur at a pre-selected bit rate. The system includes a computer having a digital output line which can be turned on and off by the computer at any time. The computer also has an internal timer which is programmed to generate timing signals at a frequency which is an integer multiple n of the pre-selected bit rate. An LED is operably connected to the digital output line so that the computer can switch the LED on and off at any time through the digital output line. An application program runs on the computer. The application program monitors the timing signals to transmit individual data bits of the binary data stream at corresponding n^{th} timing signals. Specifically, the application program turns the LED on to create an optical signal edge at a particular n^{th} timing signal if and only if the data bit corresponding to said particular n^{th} timing signal has a '0' value. The application program then monitors the timing signals to turn the LED back off at an intermediate timing signal which occurs after said particular n^{th} timing signal but before the next n^{th} timing signal. The disclosed embodiment of the system includes a light wand having a distal end which is shaped to register against the face of the receiving watch. This aids the user in aligning the LED with the receiving sensor of the watch.

7 Claims, 9 Drawing Sheets



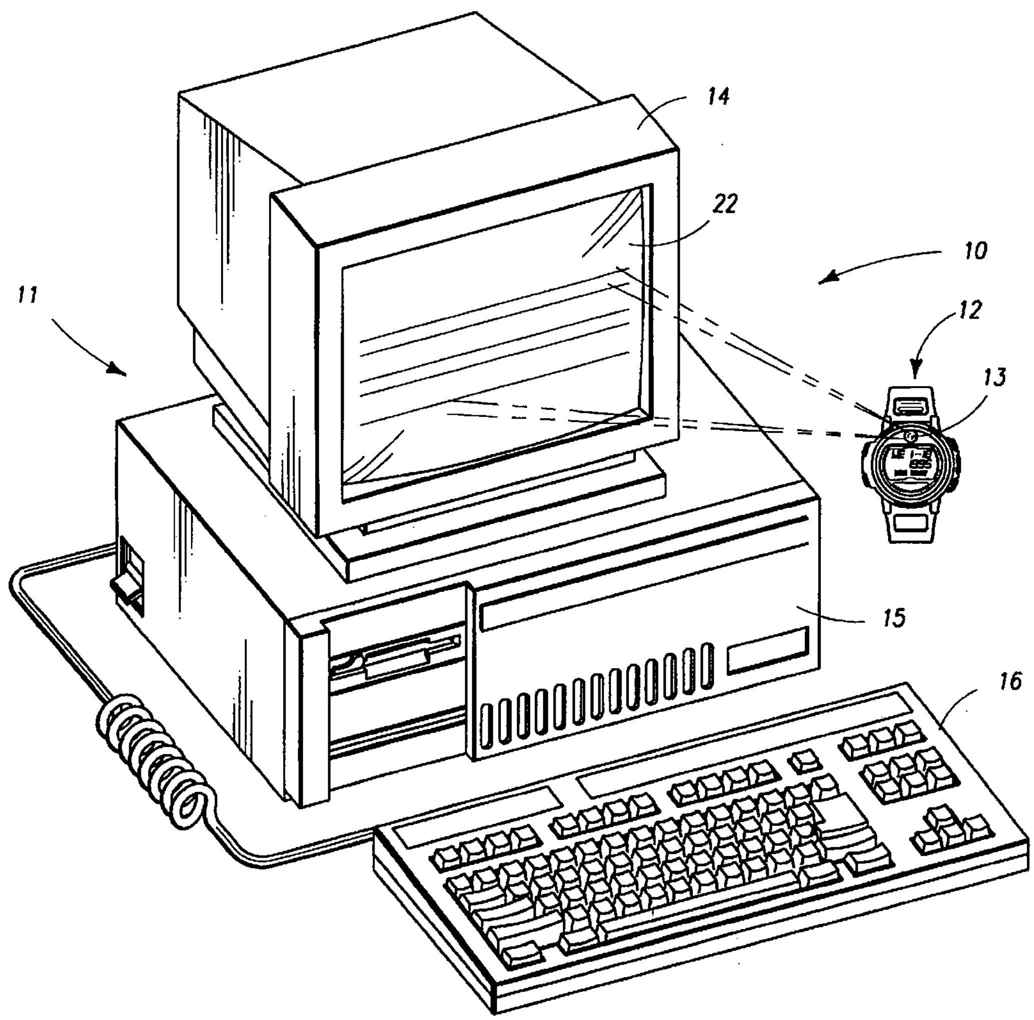


Fig 1

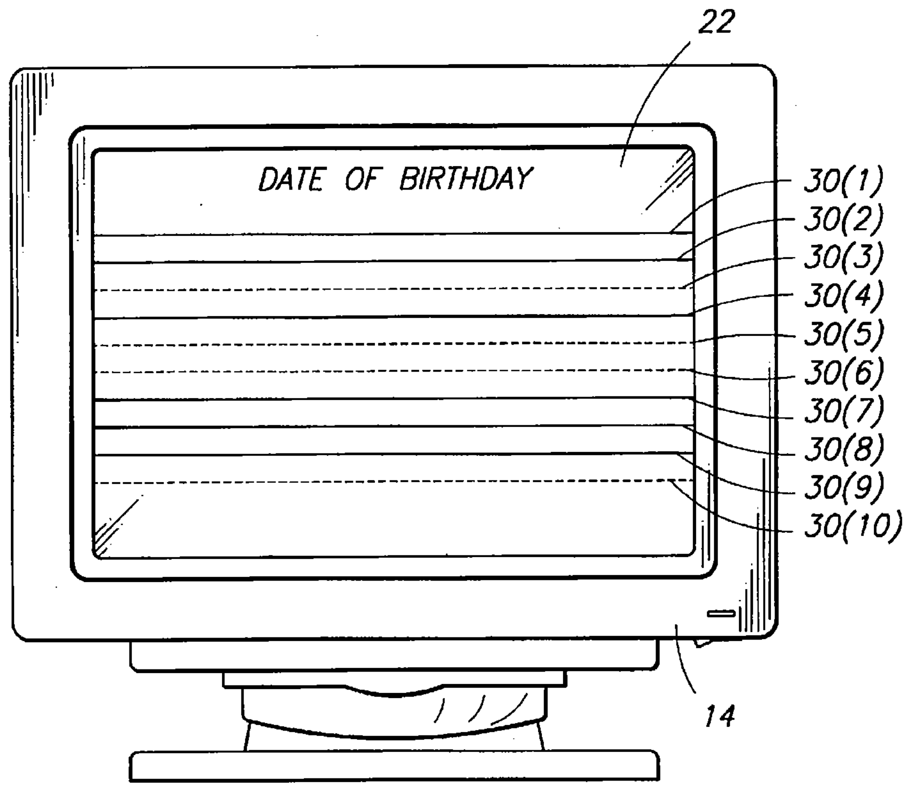

22
DATE OF BIRTHDAY
30(1)
30(2)
30(3)
30(4)
30(5)
30(6)
30(7)
30(8)
30(9)
30(10)
14

Fig 2

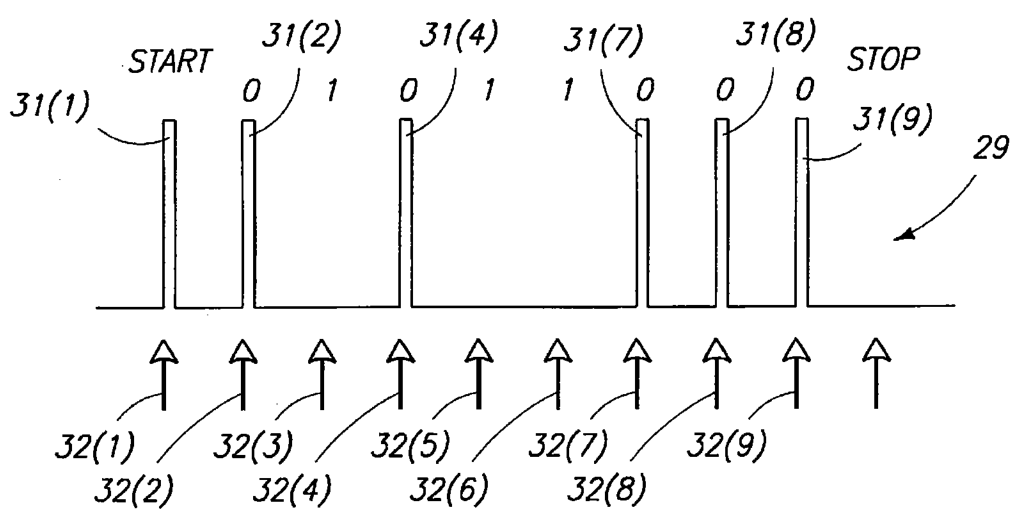

START
31(1)
31(2)
0
1
31(4)
0
1
1
31(7)
0
31(8)
0
0
STOP
31(9)
29
32(1)
32(2)
32(3)
32(4)
32(5)
32(6)
32(7)
32(8)
32(9)

Fig 3

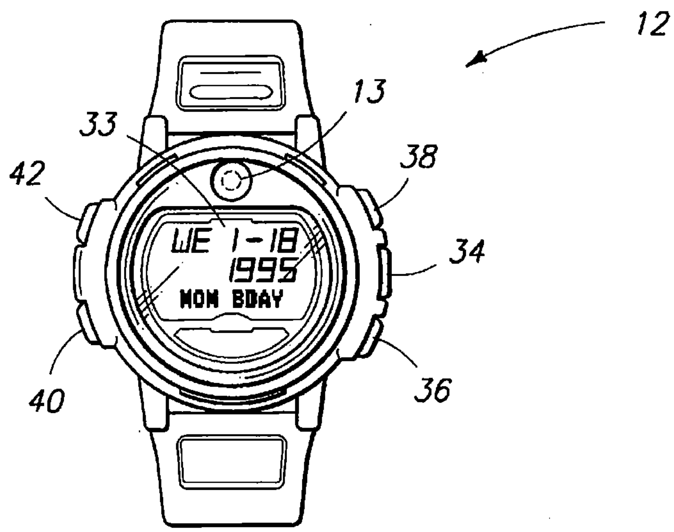

12
13
33
38
42
34
40
36
WE 1-18
1995
MON BDAY

Fig 4

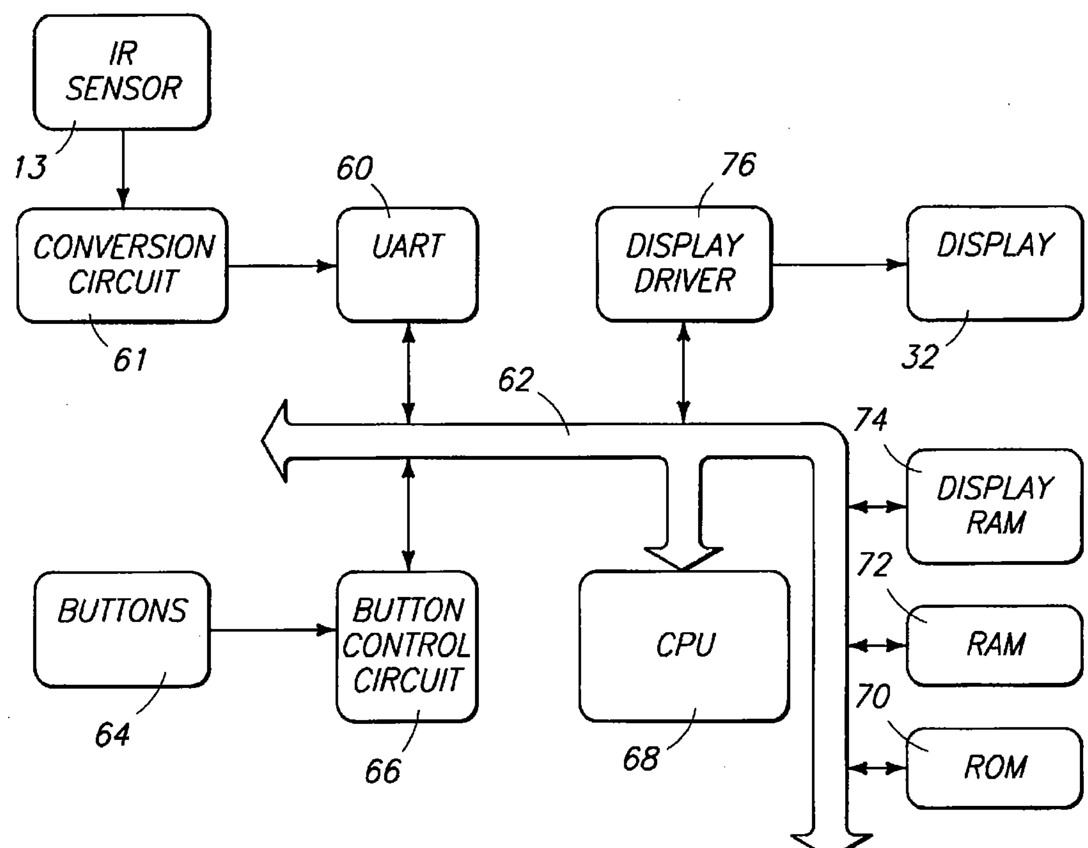

IR SENSOR
13
CONVERSION CIRCUIT
61
60
UART
76
DISPLAY DRIVER
DISPLAY
32
62
74
DISPLAY RAM
72
RAM
70
ROM
BUTTONS
64
BUTTON CONTROL CIRCUIT
66
CPU
68

Fig 5

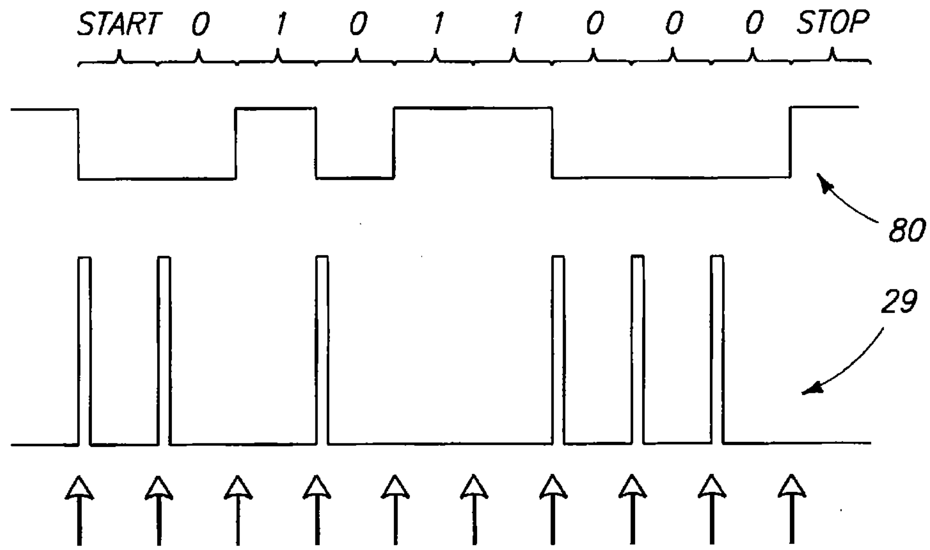

START 0 1 0 1 1 0 0 0 STOP
80
29

Fig 6

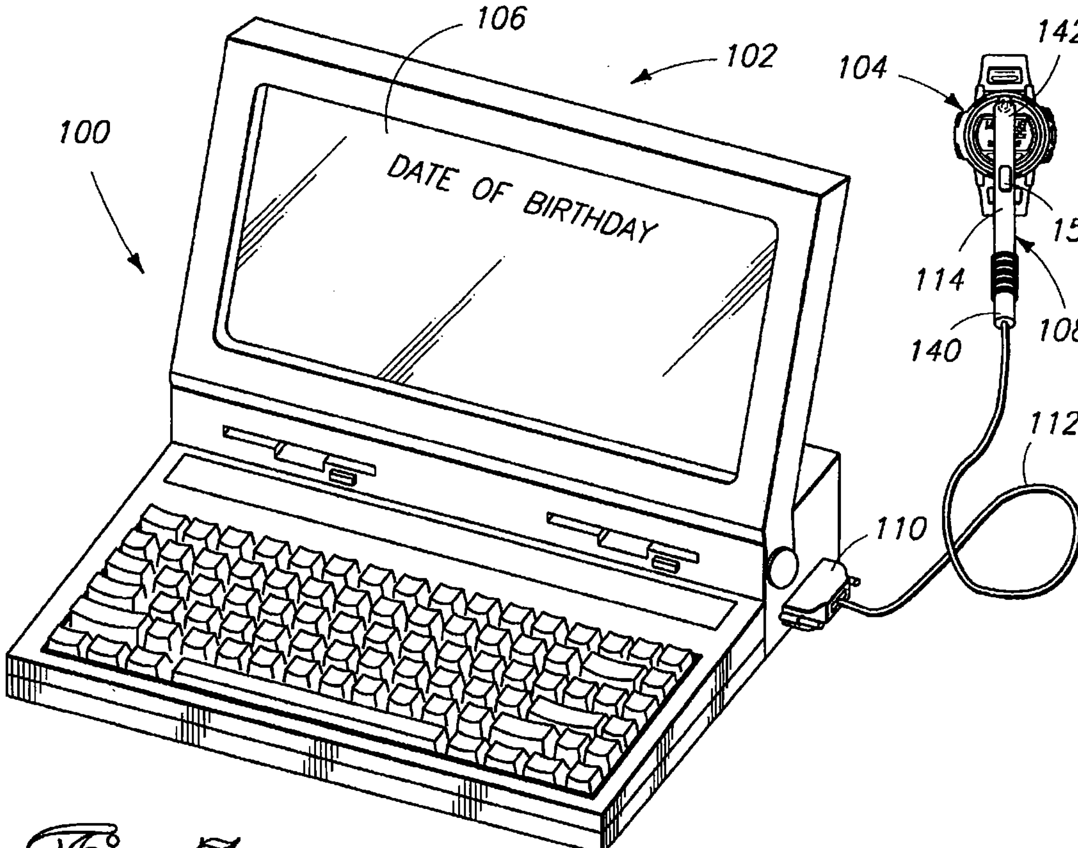

106
102
104
142
100
DATE OF BIRTHDAY
158
114
108
140
112
110

Fig 7

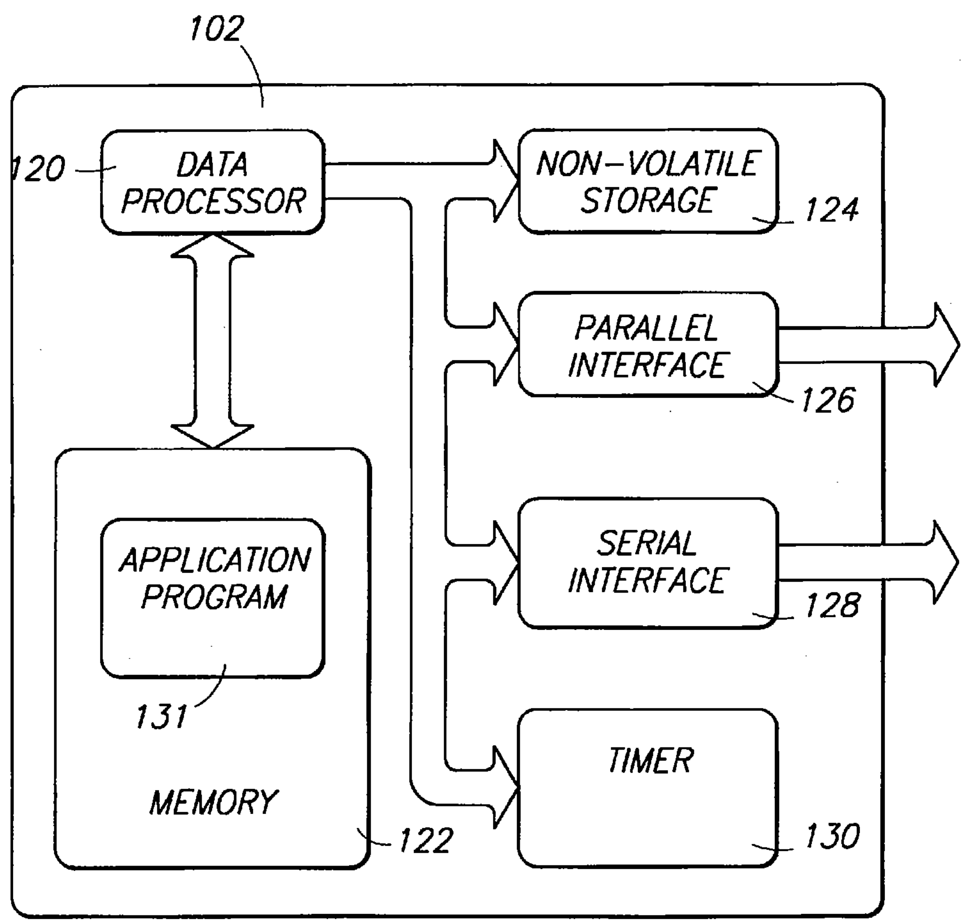

102
120
DATA PROCESSOR
NON-VOLATILE STORAGE
124
PARALLEL INTERFACE
126
SERIAL INTERFACE
128
APPLICATION PROGRAM
131
MEMORY
122
TIMER
130

Fig 8

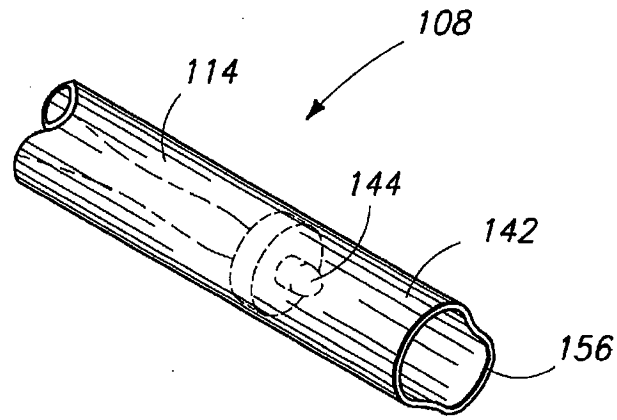


Fig 9

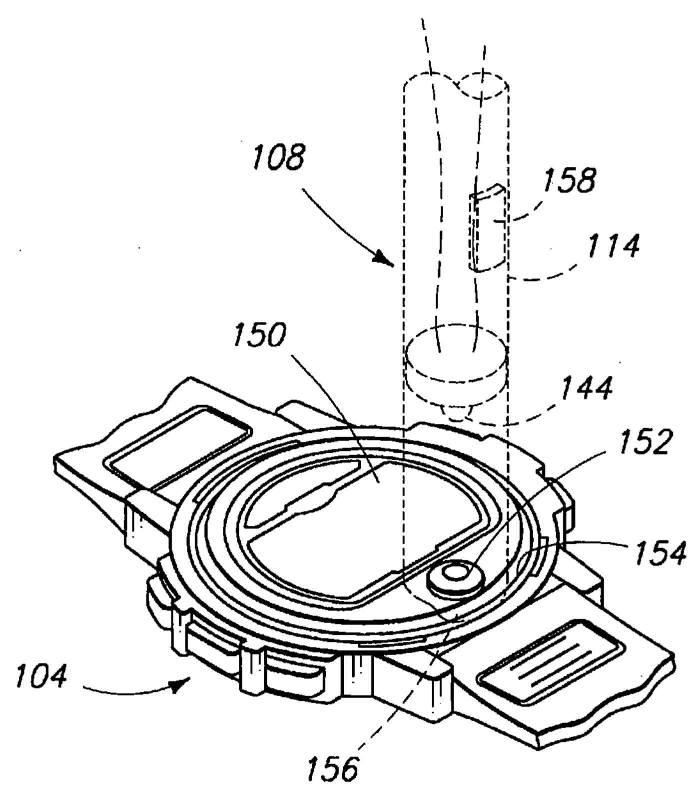


Fig 10

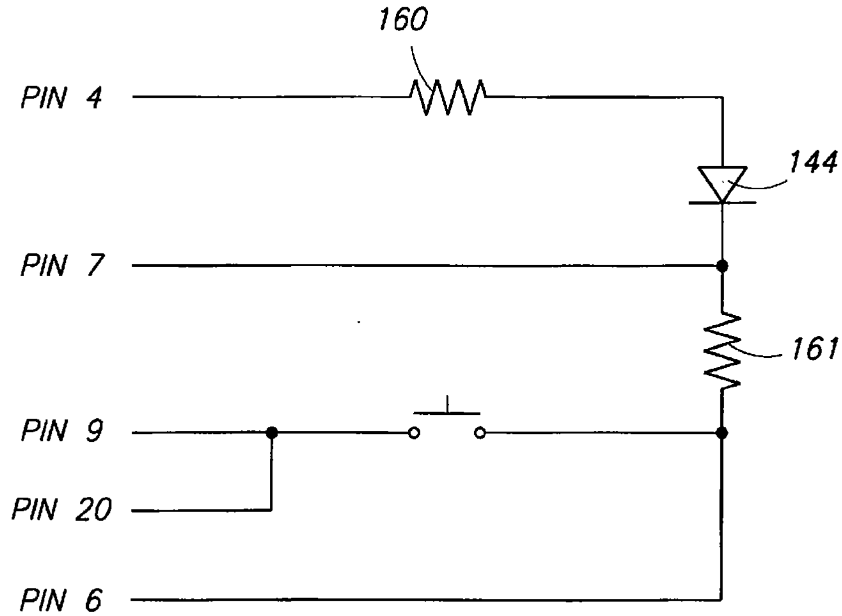


Fig 11

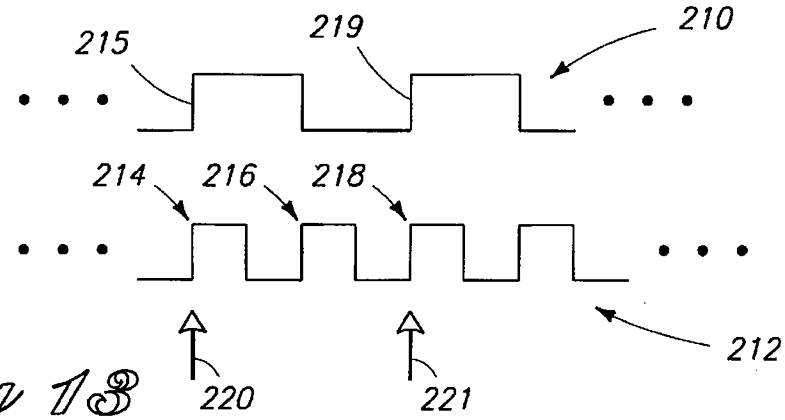


Fig 13

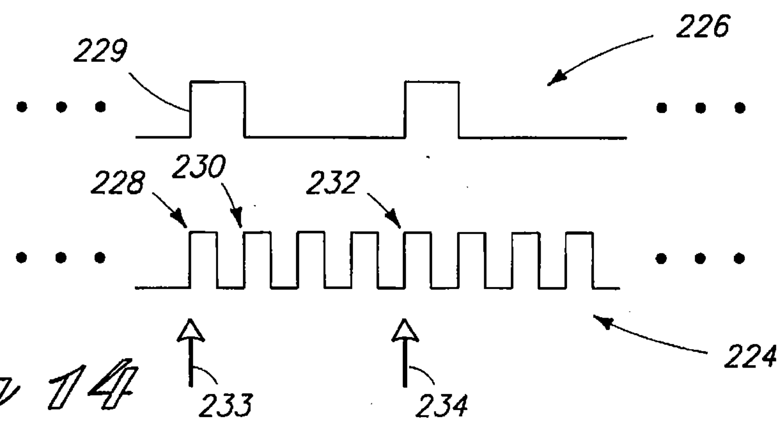


Fig 14

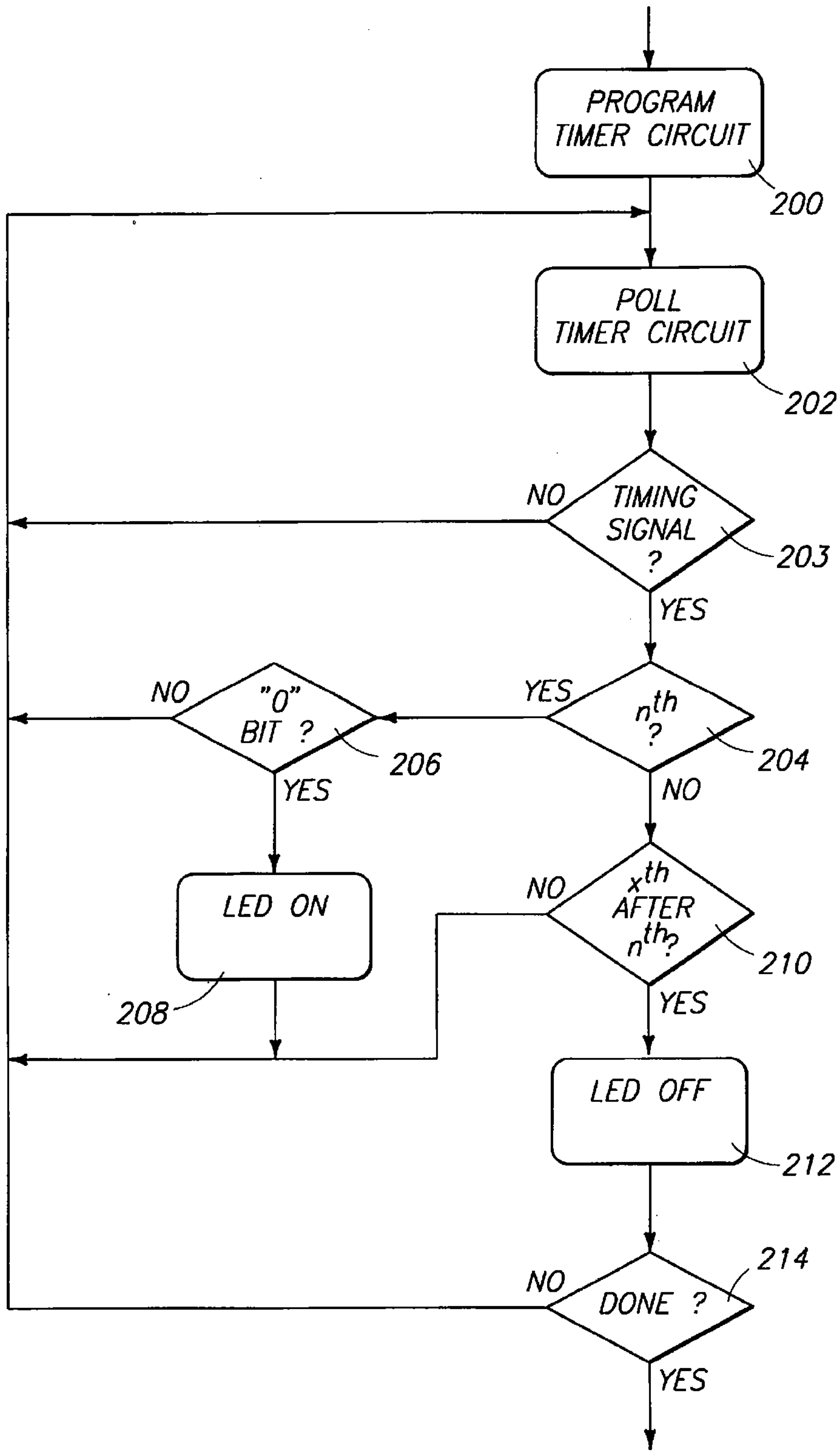

PROGRAM
TIMER CIRCUIT
200
POLL
TIMER CIRCUIT
202
NO
TIMING
SIGNAL
?
203
YES
NO
"0"
BIT ?
206
YES
nth
?
204
NO
LED ON
208
NO
xth
AFTER
nth?
210
YES
LED OFF
212
214
NO
DONE ?
YES

Fig 12

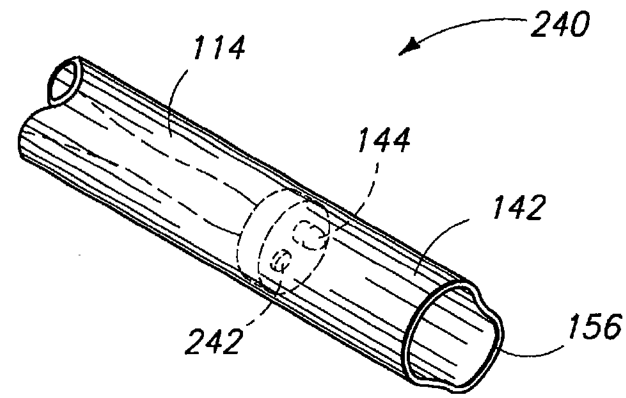

240
114
144
142
156
242

Fig 15

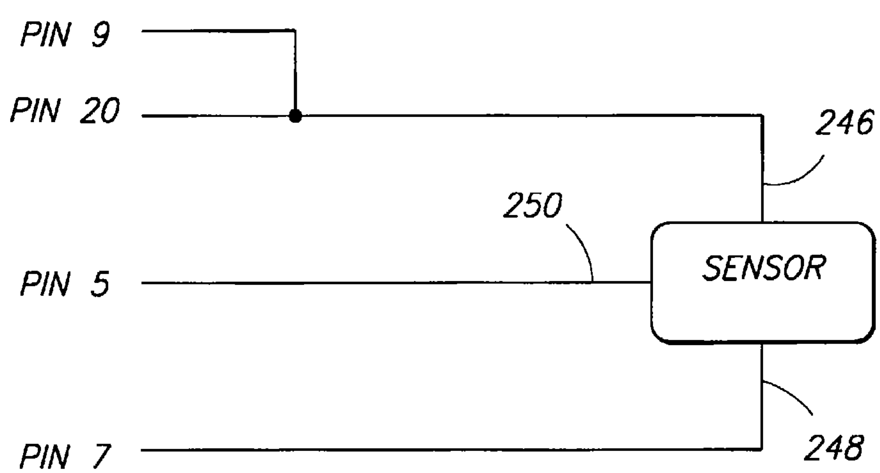

PIN 9
PIN 20
246
250
PIN 5
SENSOR
PIN 7
248

Fig 16

OPTICAL WAND HAVING AN END SHAPED TO REGISTER TO THE SURFACE OF A PORTABLE DEVICE TO ALIGN RESPECTIVE OPTICAL ELEMENT PAIRS FOR DATA TRANSFER

TECHNICAL FIELD

This invention relates to systems and methods for transferring a binary data stream in a serial edge-based transmission format between a computer and a portable information device using a peripheral device interface of a desktop computer.

BACKGROUND OF THE INVENTION

In recent years, there has been an increasing use of compact, pocket-size electronic personal organizers that store personal scheduling information such as appointments, tasks, phone numbers, flight schedules, alarms, birthdays, and anniversaries. Some of the more common electronic organizers are akin to hand-held calculators. They have a full input keyboard with both numeric keys and alphabet keys, as well as special function keys. The organizers also have a liquid crystal display (LCD) which often displays full sentences and rudimentary graphics.

Pocket-size personal organizers prove most useful to busy individuals who are frequently traveling or always on the move from one meeting to the next appointment. Unfortunately, due to their hectic schedules, these individuals are the people most likely to forget their personal organizers during the frantic rush to gather documents, files, laptops, cellular phones, and travel tickets before heading off to the airport or train depot. It would be desirable to reduce the number of electronic devices that these individuals need to remember for each outing.

Electronic watches have evolved to the point that they can function as personal organizers. Like the pocket-size devices described above, such watches can be programmed with certain key appointments, tasks, phone numbers, flight schedules, alarms, birthdays, and anniversaries. Since watches are part of everyday fashion attire, they are more convenient to carry and less likely to be forgotten by busy people. However, it is much more difficult to enter data into a watch than it is to enter the same data into a pocket-size personal organizer. This difficulty is due in large part to the limited number of input buttons and display characters available on reasonably-sized watches. Most watches are limited to having only four to six input buttons. A wearer programs a watch by depressing one or more buttons several times to cycle through various menu options. Once an option is selected, the user depresses another button or buttons to input the desired information. These input techniques can be inconvenient and difficult to remember. Such techniques are particularly inconvenient when a wearer wishes to enter an entire month's schedule. Although watches have been made with larger numbers of input keys, such watches are usually much too large for comfort, and tend to be particularly unattractive.

Apart from personal organizers, it is common for many people to maintain appointment calendars and task lists on their personal computers. One example time management software is Microsoft's® Schedule+™ for Windows™ which maintains daily appointment schedules, to-do lists, personal notes, and calendar planning. This information is often a duplicate of that maintained on the portable personal organizer.

Timex Corporation of Middlebury, Conn., has recently introduced the Timex® Data-Link™ watch. This watch utilizes new technology for transferring information from a personal computer to a watch. The face of the watch has an optical sensor which is connected to a digital serial receiver, better known as a UART (universal asynchronous receiver/transmitter). The watch expects to receive a serial bit transmission in the form of light pulses at a fixed bit rate. A pulse represents a binary '0' bit, and the absence of a pulse represents a binary '1' bit.

The CRT (cathode ray tube) or other scanned-pixel display of a personal computer is normally used to provide light pulses to the watch. Although it appears to a human viewer that all pixels of a CRT are illuminated simultaneously, the pixels are actually illuminated individually, one at a time, by an electron beam which sequentially scans each row or raster line of pixels beginning with the top raster line and ending with the bottom raster line. It is this characteristic of a CRT and of other line-scanning display devices which is utilized to transmit serial data to the Data-Link™ watch.

To transfer data to the watch, the watch is held near and facing the CRT. The computer is programmed to display a sequence of display frames in which spaced data transmission raster lines represent individual bits of data. Lines are illuminated or not illuminated, depending on whether they represent binary '0' bits or binary '1' bits. Each line appears as a continuous light pulse of a finite duration to the receiving watch. The watch recognizes an illuminated line as a binary '0' bit. It recognizes a non-illuminated line as a binary '1' bit. Generally, integral numbers of "words" of ten bits are transmitted in a single CRT display frame: eight data bits, a start bit, and a stop bit. As used herein, the term "display frame" means a single screen-size image made up of a matrix of pixels which form a plurality of raster lines. A display frame is generally created by sequentially illuminating or refreshing the raster lines of the display device.

FIG. **1** shows a system **10** as described above. System **10** includes a computer or computer system **11** and a portable or external information receiving device in the form of programmable Data-Link™ watch **12**. Computer **11** includes a frame or raster scanning graphics display device **14**, a central processing unit (CPU) **15** having a data processor, memory, and I/O components, and a keyboard **16** (or other input device).

Visual display device **14** is preferably a CRT (cathode ray tube) monitor such as commonly used in personal desktop computers. The graphics display device displays sequential display frames containing graphical images on its monitor screen **22**. A "display frame" or "frame" means a single, two-dimensional, screen-size image made up of a matrix of pixels. The pixels form a plurality of available raster lines for each display frame.

The individual pixels and raster lines of a CRT are illuminated individually by an electron beam (i.e., the cathode ray) which sequentially scans each raster line beginning with the top raster line and ending with the bottom raster line. The beam is deflected horizontally (in the line direction) and vertically (in the field direction) to scan an area of the screen to produce a single display frame. The electron beam strikes phosphors positioned at the screen of the CRT monitor to cause them to glow. The phosphors are arranged according to a desired pixel pattern, which is customarily a matrix of rows and columns. Conventional color VGA monitors typically have a resolution of 640×480 pixels or better. The process of scanning all raster lines a single time and returning the electron beam from the bottom to the top of the display is referred to as a "frame scan."

The linear scanning electron beam of CRT **14** is utilized to transfer a binary data stream between computer **11** and

watch **12**. Specifically, computer **11** uses selected, spaced raster lines of CRT **14** for serial bit transmission to watch **12**. Application software loaded in CPU **15** generates a sequence of display frames having changing patterns of raster lines that are displayed on CRT **14**. The lines appear at watch **12** as a series of optical pulses. Watch **12**, through optical sensor **13**, monitors the illumination of the raster lines of the sequential display frames to reconstruct the transmitted data.

FIG. **2** shows a specific pattern of selected and spaced raster lines used to transmit data to watch **12**. Assuming that each frame transmits a single 8-bit byte with start and stop bits, ten raster lines **30(1)**–**30(10)** (out of a much larger total number of available raster lines) are selected for transmitting data. These raster lines will be referred to herein as "data transmission raster lines," as opposed to other, intervening raster lines which will be referred to as "unused raster lines." Solid lines in FIG. **2** represent data transmission raster lines which are illuminated. Dashed raster lines in FIG. **2** represent data transmission raster lines which are not illuminated. Each data transmission raster line position conveys one data bit of information. Bits having a first binary value, such as a value '0', are represented by illuminated data transmission lines (e.g., lines **30(1)**, **30(2)**, **30(4)**, and **30(7)**–**30(9)**) and bits having a second binary value, such as a value '1', are represented by non-illuminated data transmission lines (as illustrated pictorially by the dashed lines **30(3)**, **30(5)**, **30(6)**, and **30(10)**). The data transmission raster lines are spaced at selected intervals, with intervening unused or non-selected raster lines, to produce a desired temporal spacing appropriate for the data receiving electronics of watch **12**.

For each programming instruction or data to be transmitted to the watch, the software resident in the CPU **15** causes the CRT monitor **14** to selectively illuminate the appropriate data transmission raster lines representing '0' bits by scanning the associated pixels. The selected data transmission lines that represent '1' bits are left non-illuminated. The middle eight lines **30(2)**–**30(9)** represent one byte of programming information being optically transmitted to watch **12**. Top line **30(1)** represents a start bit and bottom line **30(10)** represents a stop bit that are used for timing and error detection. Because of the scanning nature of the cathode ray of CRT monitor **14**, these patterns produce a serial light emission from CRT monitor **14** which is representative of a serial bit stream. Each display frame in FIG. **2** represents one byte. A new line grouping is presented for each sequential display frame so that each such display frame represents a different data byte. Two or more bytes could optionally be transmitted in each display frame.

The display of FIG. **2** implements a serial, edge-based, optical transmission format as shown by example signal **29** in the timing diagram of FIG. **3**, in which the horizontal direction indicates time and the vertical direction indicates optical signal intensity. Individual bits of the transferred binary data stream have first and second binary values which are represented in this transmission format by the presence or absence of optical signal edges at what are referred to herein as "mark times" **32(1)**–**32(9)**. The mark times are specified to occur at a pre-selected bit rate such as 1024 bits/second or 2048 bits/second. They are represented in FIG. **3** by the vertical arrows beneath signal **29**. To work with the current implementation of the Data-Link™ watch, the pre-selected bit rate should be approximately equal to 2048 bits/second.

This type of signal has the characteristic of returning to a "low" value before every transmitted bit. This type of transmission format is necessitated by the nature of a scanning device such as CRT **14**. The longest continuous optical pulse duration which can be generated with CRT **14** is the that of a horizontal raster line. This is because the electron beam of the CRT is deactivated between lines. The duration of a single raster line is significantly less than the time between mark times at practical bit rates.

The start bit of a single byte is represented in FIG. **2** by illuminated horizontal raster line **30(1)**. Illuminated raster line **30(1)** produces a light pulse **31(1)** as shown in FIG. **3** of a relatively short duration. The rising edge of light pulse **31(1)** occurs at a first mark time **32(1)**. The first bit of the transmitted byte is a "0", and is represented in FIG. **2** by illuminated horizontal raster line **30(2)**. Illuminated raster line **30(2)** produces a light pulse **31(2)** (FIG. **3**). The rising edge of light pulse **31(2)** occurs at a second mark time **32(2)**. The second bit of the transmitted byte is a "1", and is represented in FIG. **2** by non-illuminated horizontal raster line **30(3)**. Non-illuminated raster line **30(3)** produces no light pulse and no rising edge at the third mark time **32(3)**. The third bit of the transmitted byte is a "0", and is represented in FIG. **2** by illuminated horizontal raster line **30(4)**. Illuminated raster line **30(4)** produces a light pulse **31(4)**. The rising edge of light pulse **31(4)** occurs at a fourth mark time **32(4)**. The remaining bits of the byte are transmitted in a similar manner, followed by a stop bit which is represented by non-illuminated raster line **30(1)**.

FIG. **4** shows an external face of programmable watch **12**, which is illustrated for discussion proposes as the Timex® Data-Link™ watch. Other watch constructions as well as other portable information devices can be used in the context of this invention. Watch **12** includes a small display **33** (such as an LCD), a mode select button **34**, a set/delete button **36**, next/previous programming buttons **38** and **40**, and a display light button **42**. Optical sensor **13** is positioned adjacent to display **32**. In the programming mode, display **32** indicates the programming option, and what data is being entered therein. During the normal operational mode, display **32** shows time of day, day of week, or any other function common to watches.

Referring now to FIG. **5**, watch **12** includes a CPU (Central Processing Unit) **68** for performing data processing tasks, a ROM (Read Only Memory) **70** for storing initial power-up programs and other identification information, and a RAM (Random Access Memory) **72** for data storage. ROM **70** has an example capacity of approximately 16 Kbytes, while RAM **72** has an example capacity of 1 Kbyte. A display RAM **74** is provided to temporarily store data used by display driver **76** to depict visual information on display **32**. These components can be incorporated into a single microprocessor-based integrated circuit. One appropriate microprocessor IC is available from Motorola Corporation as model MC68HC05HG.

Watch **12** has an optical sensor **13** which is coupled to a digital serial receiver or UART **60**. UART **60** is a conventional, off-the-shelf circuit which receives data in eight-bit words surrounded by start and stop bits. However, UART **60** must receive a conventional NRZ (non-return to zero) or level-based signal—in contrast to the edge-based signal illustrated in FIG. **3**. Therefore, watch **12** includes conversion circuitry **61** to produce a level-based or NRZ serial signal from the edge-based signal generated by computer **11** and CRT **14**. Such conversion circuitry consists of a retriggerable monostable oscillator. Conversion circuitry **61** also includes amplifier and filter circuits.

FIG. **6** shows a level-based signal **80** after conversion by conversion circuitry **61**. For reference, the edge-based signal

29 of FIG. 3 is shown below level-based signal 80. The initial start bit pulse 31(1) of FIG. 3 is inverted and extended by conversion circuitry 61 until the next mark time. The remaining data bits and stop bit are similarly extended so that signal 80 only changes level when a bit has a different value than the previous bit. This is in contrast to signal 29 of FIG. 3, where the signal always returns to a "low" value before the next bit.

The output of conversion circuitry 61 is fed to UART 60. UART 60 is coupled to an internal bus 62, which is preferably an eight-bit bus. Inputs received from the control buttons on the watch, referenced generally by box 64, are detected and deciphered by button control circuit 66 and placed on bus 62.

To program the watch, the computer is first loaded with a compatible time management software and optical pattern generating software. One example time management software is Microsoft's® Schedule+™ for Windows™ and a suitable optical pattern generating software is Timex® Data-Link™ communications software. The user selects a desired option from a menu of choices displayed on the monitor in a human-intelligible form. For instance, suppose the user wants to enter his/her appointments and tasks for the month of January, including a reminder for his/her mother's birthday on Jan. 18, 1995. The user inputs the scheduling information on the computer using a keyboard and/or mouse input device. The user then sets the watch to a programming mode using control buttons 34–40 and holds optical sensor 13 in juxtaposition with monitor screen 22. A sequence of changing optical patterns having horizontal contiguously-scanned lines begin to flash across the monitor screen as shown in FIG. 3 to optically transmit data regarding the various appointments and tasks. In about 20 seconds, the system will have transmitted as many as 70 entries, including the birthday reminder. These entries are kept in data RAM 72.

The system described above is extremely convenient and easy to use. However, it does have a significant drawback in that it cannot be used with some types of computer displays. Specifically, LCD screens do not generate light pulses which can be sensed by the optical sensor of the Data-Link™ watch. Accordingly, another method must be used to program the watch from laptop computers which use non-scanned displays.

It has been contemplated that communication from such computers to the Data-Link™ watch could be accomplished LED's with (light-emitting diodes) connected to the serial printer interfaces of the computers. However, this would require special conversion circuitry to convert the level-based serial signal produced by a serial printer interface to the edge-based serial format expected and required by the Data-Link™ watch. It would be desirable to eliminate the need for such special conversion circuitry. Another problem with the previously-contemplated approach is that users might have difficulty in correctly positioning the LED relative to the watch and in signaling the computer when alignment has been achieved. Again, it would be desirable to eliminate this concern.

SUMMARY OF THE INVENTION

The invention described below utilizes the peripheral device interface of a computer, in conjunction with an internal timer of the computer, to produce an edge-based serial signal such as illustrated in FIG. 3 without requiring conversion circuitry. In the embodiment disclosed herein, the computer programs its internal timer to generate timing signals at a frequency which is an integer multiple n of the desired bit rate, wherein every n^{th} timing signal occurs at a mark time. A light emitting element such as an LED is connected to a bit output line of the peripheral device interface so that the computer can switch the light emitting element between on and off states at any time through the output line. An application program monitors the timing signals and transmits individual data bits of a binary data stream at corresponding n^{th} timing signals. Specifically, the application program switches the state of the light emitting element from a first to a second of its on and off states to create an optical signal edge at a particular n^{th} timing signal if and only if the data bit corresponding to said particular n^{th} timing signal has the first binary value. The application switches the light emitting element back to its first state at an intermediate timing signal which occurs prior to the next n^{th} timing signal.

Further aspects of the invention include an adapter for connecting the light emitting element to either the parallel or the serial printer interface of a computer without requiring special conversion circuitry. The invention also includes a light wand for aligning the light emitting element with the optical sensor of the receiving watch. The wand has a button which a user can press to signal the computer to begin data transfer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of a system for serially transferring data to a programmable watch from a desk-top computer with a CRT.

FIG. 2 is diagrammatic front view of a CRT monitor depicting a display frame having contiguously-scanned lines used to convey bits of information to the programmable watch.

FIG. 3 is a timing diagram showing an optical signal generated by the CRT monitor of FIG. 2.

FIG. 4 is a diagrammatic front view of the programmable watch of FIG. 1.

FIG. 5 is a simplified block diagram of the internal components of the programmable watch of FIG. 1.

FIG. 6 is a timing diagram of a serial logic signal produced internally by the programmable watch in response to the signal shown in FIG. 3. The optical signal of FIG. 3 is also incorporated in FIG. 6 for purposes of reference.

FIG. 7 is a diagrammatic view of a system in accordance with the invention for transferring a binary data stream between a computer and a portable information device.

FIG. 8 is a simplified block diagram of a computer such as shown in FIG. 7.

FIG. 9 is a distal-end perspective view of a light wand in accordance with one embodiment of the invention.

FIG. 10 is a top perspective view of a watch and light wand in accordance with said one embodiment of the invention.

FIG. 11 is a schematic diagram of a light wand and associated adapter in accordance with said one embodiment of the invention.

FIG. 12 is a flow diagram showing methodical steps implemented by the system of FIG. 7.

FIG. 13 is a timing diagram showing an example timing signal and edge-based signal in accordance with the invention.

FIG. 14 is a timing diagram showing another example timing signal and edged based signal in accordance with the invention.

FIG. 15 is a distal-end perspective view of an alternative-embodiment light wand in accordance with the invention.

FIG. 16 is a schematic diagram of the light wand of FIG. 15 and its associated adapter.

DETAILED DESCRIPTION

FIG. 7 shows a system 100 in accordance with an exemplary embodiment of the invention for transferring a binary data stream between a computer 102 and a portable information device 104. As will be further described below, system 100 uses an optical element pair to transfer the binary data stream. Portable information device 104 has a first member of the optical element pair, which is preferably an optical sensor for detecting serially transmitted binary data. The second member of the optical element pair is preferably a light emitting element associated with computer 102 for serially transmitting binary data to portable information device 104.

Computer 102 is a laptop computer having an LCD or other non-scanning screen 106 which is unsuitable for normal transmission of data to portable information device 104. Portable information device 104 is a Timex® Data-Link™ watch, which can be configured to function as a portable personal information manager. The invention is described herein within the context of a programmable watch. However, other forms of external devices can be used, such as pagers and personal digital assistants (PDA's). As used herein, "portable information device" means a small, portable, electronic apparatus that has limited power resources and limited rewritable memory capacity. The Data-Link™ watch, for example, is presently constructed with a rewritable memory capacity of approximately 1 Kbyte.

System 100 includes a light wand 108 which computer 102 uses to produce a serial, edge-based optical signal as described above with reference to FIG. 3. Light wand 108 is used in conjunction with a digital output line of the computer. Specifically, light wand 108 has a light emitting element which connects to and is responsive to a bit output line of the computer. The digital output line is of a type which can be turned on and off by the computer at any time, on a real-time basis. The serial transmit line associated with serial printer interface 128, commonly referred to as the TX line, does not satisfy this criteria—computer 102 cannot control the state of the TX line on a real-time basis. Rather, the TX line is controlled by a UART (universal asynchronous receiver/transmitter). Computer 102 controls the TX line only indirectly by writing bytes to the UART. The UART, in turn, produces an NRZ, level-based, serial signal through the TX line at a bit rate which is controlled by the UART itself in conjunction with an external oscillator. It is not possible for computer 102 to create an edge-based signal, such as shown in FIG. 3, through the TX line of the serial printer interface.

FIG. 8 shows pertinent internal components of computer 102, including a data processor 120, volatile program memory 122, non-volatile storage memory 124, and two peripheral device interfaces. In this case, the peripheral device interfaces include a parallel printer interface 126 and a serial printer interface 128. Other types of peripheral device interfaces could also be used, such as a CRT interface. Computer 102 further includes an internal general purpose programmable timer circuit 130 which can be used to generate periodic interrupts or for other purposes by application software running on computer 102. Such a timer is found in most types of desktop or personal computers. The illustrated computer system is an IBM®-compatible system, although other architectures, such as Apple®-compatible systems, can be employed. In IBM®-compatible systems, the internal timer is referred to as an 8253 timer. The 8253 timer actually incorporates three timer circuits. Two are used by the computer's internal operating system, while a third is available for application programs. The features and methods described below utilize this third timer circuit.

Parallel printer interface 126 is of a type commonly found in IBM®-compatible and other systems, popularly referred to as a Centronics-type interface. Serial printer interface 128 is similarly a common feature of desktop computers, and conforms to the RS-232 standard which is well-known in the industry. Each interface is associated with its own electrical connector (not shown) for connection to external devices. Most popular desktop systems, such as the IBM®-compatible system shown, use industry-standard "DB-25" connectors for their parallel and serial interfaces. The parallel printer interface has a plurality of bit lines which can be individually configured as inputs or outputs. The binary state of the bit input lines can be monitored at any time by reading from a control register. The binary state of the bit output lines can similarly be modified at any time by writing to a control register. The serial printer interface has serial transmission and reception lines, referred to respectively as TX and RX lines, as well as a number of control input and output lines. The TX and RX lines cannot be directly modified by computer 102. Rather, they are under control of a UART circuit which normally processes data stream bits at a specified bit rate. The control input and output lines, however, can be monitored and modified at any time by accessing one or more control registers.

Wand 108 is adapted for connection to either parallel printer interface 126 or serial printer interface 128. The digital output line referred to above is either a selected data or control output line of parallel printer interface 126 or a control output line of serial printer interface 128. The LED of wand 108 is operably connected to respond (a) to the selected output line of the parallel printer interface when wand 108 is connected to the parallel printer interface, or (b) to the control output line of the serial printer interface when wand 108 is connected to the serial printer interface. Through this connection, computer 102 is able to switch the LED between on and off states at any time to create an edge-based serial signal at a specified bit rate.

FIGS. 7 and 9–11 show wand 108 in more detail. It comprises an elongated, cylindrical hand-held housing or tube 114 having a proximal end 140 (FIG. 7) and an open distal end 142. A light emitting element or LED 144 is contained within the tube's distal end 142. LED 144 is operably connected through a flexible cable 112 to an adapter 110 which extends between tube 114 and adapter 110 for connection to a digital output line of the computer. Adapter 110 is a DB-25 connector which mates with the serial or parallel printer interface connectors of computer 102.

As best shown in FIG. 10, watch 104 has an irregular or non-planar surface about the optical sensor. More specifically, watch 104 has an upper surface 150 in which its optical sensor 152 is positioned. This surface has a circular outer periphery. A circular recess or trough 154 surrounds upper surface 150 just outside its outer periphery and adjacent optical sensor 152. Open distal end of hand-held housing 114 has a shape which is complementary to the irregular surface about optical sensor 152. The wand is formed with a protrusion 156 which extend down into trough 154 to positively register wand 108 with the non-

planar surface of watch **104** and to thereby align LED **144** relative to optical sensor **152** of watch **104**. This reduces any problems a user might have in determining where to locate the LED relative to the optical sensor of the watch. Other methods of registering wand **108** with watch **104** could optionally be employed. The LED is preferably positioned within the cylindrical housing of wand **108** to be about one inch from the optical sensor when the wand is registered against the watch.

Wand **108** further includes a depressible button or momentary contact switch **158** on housing **114**. This button is operably connected through flexible cable **112** to signal the computer to initiate optical transfer of the binary data stream.

In use, a user initially configures computer **102** for data transfer. The user then holds wand **108** against the face of watch **104**, with protrusion **156** registered and positioned in trough **154**, and then presses button **158** to begin data transfer. It has been found that this feature reduces or eliminates data transfer errors attributable to LED mis-positioning.

Referring now to the schematic of FIG. **11**, the anode of LED **144** is connected through a first resistor **160** to pin **4** of a DB-25 connector (not shown). Pin **4** of a DB-25 connector corresponds to the data-bit-**1** line of an industry-standard parallel printer interface. It is configured as an output by computer **102** and can thus be switched on and off at any time by computer **102** to switch LED **144** on and off. Pin **4** of a DB-25 connector also corresponds to the RTS (ready-to-send) line of an industry-standard serial printer interface. The RTS line is a control output line which can similarly be accessed and switched at any time by computer **102** through its UART, simply by writing to a register of the UART.

The cathode of LED **108** is connected directly to pin **7** of the DB-25 connector. This corresponds to the data-bit-**5** line of a parallel printer interface, which is configured by computer **102** as an output. The computer is programmed to fix this line at a low value to act as a ground or low voltage source for LED **144** when wand **108** is connected to the parallel printer interface. Pin **7** also corresponds to the GND (ground) line of the serial printer interface.

One terminal of button switch **158** is connected to both of pins **9** and **20** of the DB-25 connector. Pin **9** corresponds to the data-bit-7 line of a parallel printer interface (configured as an output), and pin **20** corresponds to the DTR (data terminal ready) control output line of a serial printer interface. These output lines are set high by computer **102** so that they function as high voltage sources. The other terminal of button **158** is connected through a resistor **161** to pin **7** (which functions as ground) and directly to pin **6**. Pin **6** corresponds to the data-bit-4 line of a parallel printer interface and to the DSR (data-set-ready) line of a serial printer interface. These lines are configured as inputs and polled by computer **102** to determine whether button **158** is pressed.

The interconnections shown in FIG. **11** are contained primarily within adapter **110**. With this configuration, the adapter can be connected to either a parallel printer interface or to a serial printer interface. In either case, computer **102** can control LED **144** on a real-time basis to produce an edge-based signal as shown in FIG. **3**.

When transferring information, computer **102** runs an application program **131** (FIG. **8**) to control the data transfer. The application program implements a method of transferring a binary data stream in a serial, edge-based transmission format. The methodical steps implemented by the application program are shown in FIG. **12**.

A first step **200** comprises programming or setting an internal programmable timer circuit, such as timer **130**, to generate timing signals at a frequency which is an integer multiple n of the pre-selected bit transmission rate at which watch **104** expects to receive data. As noted above, the bit rate expected by the Timex Data-Link™ watch is currently 2048 bits/second. The occurrences of these timing signals define the mark times, so that every n^{th} timing signal occurs at a mark time, and so that mark times occur at the bit transmission rate in coincidence with the timing signals. A subsequent step **202** comprises polling or monitoring the timing signals with the computer. A decision step **203** comprises determining whether a timing signal has occurred. If it has not, execution returns to step **202**. Upon detecting a timing signal, step **204** determines whether it is an n^{th} timing signal, corresponding to a mark time. If it is an n^{th} timing signal, execution proceeds to decision block **206** for determination of whether the next bit to be transmitted has a binary '0' value or a binary '1' value. If the value is '1', no action is taken and execution returns to step **202**. If the value is '0', a step **208** of turning on or illuminating LED **144** is executed. LED **144** is turned on via the selected digital output line of computer **102**. This generates an optical signal edge.

These steps result in transmitting individual data bits of the binary data stream at corresponding n^{th} timing signals. Transmitting an individual data bit comprises switching the state of the LED **144** from a first to a second of its on and off states to create an optical signal edge at a particular mark time or n^{th} timing signal if and only if the data bit corresponding to said particular n^{th} timing signal has the first binary value. Computer **102** switches LED **144** from off to on only for data bits having the '0' value. Data bits having the '1' value do not result in a signal edge.

Steps **210** and **212** comprise switching the state of the light emitting element back to its first state (off in the embodiment disclosed herein) at an intermediate timing signal which occurs between mark times after the particular n^{th} timing signal but before the subsequent n^{th} timing signal. Specifically, the intermediate timing signal occurs x timing signals after the n^{th} timing signal, where x is less than n. Step **210** determines whether the timing signal detected in step **203** is x timing signals after the last n^{th} timing signal. If not, execution returns to step **202**. If the timing signal is x timing signals after the last n^{th} timing signal, step **212** of turning LED **144** off is executed, and execution returns to step **202** for polling the timer again. These steps are repeated for individual bits of the data stream, including start and stop bits, until the data stream has been exhausted as indicated by decision block **214**.

In one embodiment of the invention, n is equal to two and the intermediate timing signal occurs one timing signal after the particular timing signal (x=1). This is illustrated in the timing diagram of FIG. **13**, which shows an optical signal **210** resulting from the transmission by computer **102** of two consecutive '0' bits. Timing signals **212** generated by timer circuit **130** are shown below signal **210**. Mark times are again illustrated by vertical arrows beneath the timing signals. At a first timing signal **214** which occurs at a first mark time **220**, computer **102** transmits the first '0' bit by switching the LED **144** on and creating a first rising edge **215**. Computer **102** continues to monitor the timing signals. The next, second timing signal **216** occurs prior to the next mark time. Upon detecting this intermediate timing signal, computer **102** switches LED **144** back off. Since n is equal to two in this case, computer **102** then monitors the timing signals, waiting for the n^{th} or second timing signal after first

timing signal 214, referenced by numeral 218. Timing signal 218 occurs at a second mark time 221. Upon detecting timing signal 218, computer 102 repeats the process of switching LED 144 on and then back off to create a pulse with a rising edge 219. If the bit to be transmitted were to have a binary value of '1', computer 102 would simply skip the step of switching LED 144 on.

In another embodiment of the invention, n is equal to four. The intermediate timing signal, however, still occurs one timing signal after each n^{th} timing signal. This is illustrated in the timing diagram of FIG. 14, where the timing signal is referenced by the numeral 224 and the optical signal is referenced by the numeral 226. At a first timing signal 228 which occurs at a first mark time 233, computer 102 transmits the first '0' bit by switching the LED 144 on, thereby creating a an optical pulse with a leading edge 229. Computer 102 continues to monitor the timing signals. The next, second timing signal 230 occurs prior to the next mark time 234. Upon detecting this intermediate timing signal, computer 102 switches LED 144 back off. Computer 102 then monitors the timing signals, waiting for the next n^{th} or fourth timing signal after first timing signal 224, referenced by numeral 232. Timing signal 232 occurs at a second mark time 234. Upon detecting timing signal 232, computer 102 repeats the process of switching LED 144 on and then back off.

In another embodiment of the invention, not illustrated, n is equal to sixteen. The intermediate timing signal in this embodiment occurs three timing signal after each n^{th} timing signal. This results in a data signal having a duty cycle of 3/16ths (each optical pulse is present for 3/16ths of the total bit time).

FIG. 16 shows a still further embodiment of the invention in which a wand 240 has both a light emitting element and its own optical sensor 242 for receiving a binary optical signal from an external source. Wand 240 is similar to wand 108, already described, and the same reference numerals are therefore used to designate identical components of the two embodiments. Wand 240 is used for bi-directional data transfer. Optical sensor 242 is connected through flexible cable 112 to adapter 110, which is in turn connected to a digital input line of computer 102. Through such a connection, computer 102 can monitor the on and off states of the optical signal received by the optical sensor at any time when the adapter is connected to either the parallel or the serial printer interface.

FIG. 15 shows the electrical connections of optical sensor 242 in more detail. Optical sensor 242 is a three-terminal device, having a power terminal 246, a ground terminal 248, and a signal output terminal 250. Power terminal 246 is connected to pins 9 and 20 of the adapter's DB-25 connector. As already discussed, these pins are fixed at a high voltage to provide power to optical sensor 242. Ground terminal 248 is connected to pin 7, which is fixed at a low voltage as already described. Signal output terminal 250 is connected to pin 5. Pin 5 corresponds to data-bit-3 in a parallel printer interface. Data-bit-3 is configured as an input so that computer 102 can monitor the state of a received optical signal. Pin 5 corresponds to the CTS (clear-to-send) control line of a serial printer interface. Computer 102 can similarly monitor this line to determine the state of a received optical signal.

Reception of a data stream using wand 240 occurs in an analogous manner to transmitting data. A computer application program monitors the timing signals generated by timer circuit 130 and polls the digital input line associated with the optical sensor. The line is polled at least every n^{th} timing signal to detect signal edges of the optical signal at the mark times. Preferably, the application program polls the digital input line at every n^{th} timing signal and at at least one timing signal following every n^{th} timing signal. Even more preferably, the application program polls the digital input line at every timing signal to detect rising edges of an incoming optical signal and to relate those rising edges to the mark times which occur at the selected bit rate.

The various aspects and features of the invention described above allow a single, inexpensive device to be used for transferring information to a portable information device when it is not practical to complete such transfer using a CRT monitor. Even though the receiving device expects a signal of a type which cannot be automatically generated by the serial printer interface of a conventional desktop computer, the same device can be plugged into either a serial printer interface or a parallel printer interface to generate this specialized signal. Additionally, no conversion electronics are required to produce the specialized signal. As a further enhancement, the light wand of the invention reduces the difficulties users might have otherwise had in correctly positioning an LED relative to a portable information device to accomplish data transfer. It is believed that these features will significantly increase the value and user friendliness of data transfer systems such as those used in conjunction with the Timex®Data-Link™ watch.

It is to be expressly understood that the claimed invention is not limited to the disclosed embodiments but encompasses other alternate embodiments that fall within the scope of the appended claims.

I claim:

1. A light wand for optically transferring, via an optical element pair, a binary data stream between a computer and a portable information device, the optical element pair comprising a light emitting element for serially transmitting binary data and an optical sensor for detecting serially transmitted binary data, the portable information device having a first member of the optical element pair, the portable information device having a surface about the first member of the optical element pair, the light wand comprising:

- a hand-held housing having a proximal end and an open distal end;
- the second member of the optical element pair being contained within the open distal end of the hand-held housing;
- a flexible cable extending from the hand-held housing for connection to an I/O line of a computer, the flexible cable being operably connected to the second member of the optical element pair;
- the open distal end of the hand-held housing having a shape which is complementary to the surface of the portable information device about the first member of the optical element pair, the distal end of the hand-held housing registering with the surface of portable information device to align the second member of the optical element pair relative to the first member of the optical element pair.

2. A light wand as recited in claim 1 wherein the surface of the portable information device about the first member of the optical element pair is non-planar.

3. A light wand as recited in claim 1 wherein the first member of the optical element pair is the optical sensor and the second member of the optical element pair is the light emitting element.

4. A light wand as recited in claim 1 and further comprising a depressible button on the housing, the depressible button being operably connected through the flexible cable to signal the computer to initiate optical transfer of the binary data stream.

5. A light wand as recited in claim 1 and further comprising an adapter which connects to either one of a computer's parallel and serial printer interfaces, the cable being connected through the adapter to the parallel printer interface when the adapter is connected to the parallel interface and to the serial interface when the adapter is connected to the serial printer interface.

6. A light wand for optically transmitting a binary data stream from a computer to a portable information device, the portable information device having an optical sensor for detecting serially transmitted binary data, and having a surface about the optical sensor, the light wand comprising:

an elongated hand-held housing having a proximal end and an open distal end;

a light emitting element contained within the open distal end of the elongated cylindrical hand-held housing for serially transmitting binary data;

an adapter which connects to the computer's peripheral device interface;

a flexible cable extending from the hand-held housing, the flexible cable being operably connected to light emit-

ting element, the flexible cable being connected through the adapter to the computer's peripheral device interface when the adapter is connected to the peripheral device interface;

the open distal end of the hand-held housing having a shape which is complementary to the surface of the portable information device about the optical sensor, the distal end of the hand-held housing registering with the surface of portable information device to align the light emitting element relative to the optical sensor of the portable information device;

a depressible button on the housing, the depressible button being operably connected through the flexible cable to signal the computer to initiate optical transfer of the binary data stream.

7. A light wand as recited in claim 6 wherein the adapter connects to either one of a computer's parallel and serial printer interfaces, the flexible cable being connected through the adapter to the parallel printer interface when the adapter is connected to the parallel printer interface and to the serial interface when the adapter is connected to the serial interface.

* * * * *

Evidence Appendix D (37 C.F.R. § 41.37(c)(1)(ix))
Copy of the Interview Summary Record Dated December 20, 2004

This Interview Summary Record was prepared by the Examiner, given to Appellants' counsel, and made part of the record after a personal interview with the Examiner conducted on December 20, 2004.

Interview Summary	Application No.	Applicant(s)
	10/086,644	SCHROCK ET AL.
	Examiner	**Art Unit**
	Thanh S Phan	2841

All participants (applicant, applicant's representative, PTO personnel):

(1) *Thanh S Phan*. (3)_____.

(2) *Tom Evans*. (4)_____.

Date of Interview: *20 December 2004*.

Type: a)☐ Telephonic b)☐ Video Conference
c)☒ Personal [copy given to: 1)☐ applicant 2)☒ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: _____.

Identification of prior art discussed: *Thinesen [US 5,050,141] and Kanzake [US 5,526,290]*.

Agreement with respect to the claims f)☐ was reached. g)☐ was not reached. h)☒ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *It was agreed that the 112 rejection is inadequate and will be withdrawn. Discussed newly added wording in the next response in term of patentability. Examiner will consider thses arguments when the next respone is received.*.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.

Examiner's signature, if required

..ımmary of Record of Interview Requirement..

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)
In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
– Application Number (Series Code and Serial Number)
– Name of applicant
– Name of examiner
– Date of interview
– Type of interview (telephonic, video-conference, or personal)
– Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
– An indication whether or not an exhibit was shown or a demonstration conducted
– An identification of the specific prior art discussed
– An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
– The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Related Proceedings Appendix (37 C.F.R. § 41.37(c)(1)(x))

None, as noted in Section (ii) above.